Exhibit 17

PLAINTIFF HARFORD COUNTY BOARD OF EDUCATION OPPOSITION TO DEFENDANTS' MOTION FOR SUMMARY JUDGMENT (HARFORD) (SD MSJ NO. 6)

EXPERT REPORT OF
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San Diego State University

May 16, 2025

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1. Introduction and summary of findings

1. I have been asked by counsel to provide my expert opinion on the relationship between social media use and mental health among adolescents. Key findings from my analysis, detailed in the report below, include:

2. Time series studies on trends in adolescent mental health strongly support social media as a key contributor to increases in adolescent depression, unhappiness, loneliness, self-harm, and suicide.

3. None of the potential alternative causes of these increases fit the time series data nearly as well as social media.

4. Correlational studies show that the more hours a day an adolescent uses social media, the more likely they are to be depressed or unhappy. These links are larger among girls.

5. Longitudinal studies show that adolescents' social media use at an initial time (i.e., Time 1) leads to depression at a later time (i.e., Time 2).

6. Experimental studies show that people who are randomly assigned to eliminate or reduce social media for two weeks or more are less lonely and less depressed, demonstrating a causal path from social media use to lower psychological well-being.

7. The totality of the evidence demonstrates a clear causal path from social media use to low psychological well-being in adolescents, as all the Bradford Hill criteria for establishing causality are met.

2. Personal background and qualifications

2.1 Background

8. I am a Professor of Psychology at San Diego State University. I have authored or coauthored 148 peer-reviewed scientific journal articles and 44 scholarly book chapters, including works on generational trends in adolescent mental health, social media use and mental health, screen time and behavioral issues among children, generational differences in teen independence, causal effects of social rejection, screen media and sleep issues, and generational trends in happiness and life satisfaction. In 2021, 2022, 2023, and 2024, Clarivate Analytics included me on its list of the top 0.1% of highly cited scientists, indicating significant and broad influence in research.

9. I have also authored or co-authored 17 books. These include *iGen* (2017), one of the first works to document the scope of the adolescent mental health crisis and to hypothesize it was linked to social media and smartphone use, and *Generations* (2023, paperback 2025), which details the impact of technological change on all six living American generations. I am also the co-author of two undergraduate textbooks (*Personality Psychology* and *Social Psychology*) that are revised every few years, requiring me to keep up with the emerging research in both fields. I regularly teach a course in personality psychology and have previously

taught courses in research methods (including at the graduate level), social psychology, cultural psychology, introductory psychology, and the history of psychology.

10. I began at San Diego State as an assistant professor in 2001, earning tenure in 2005 and being promoted to full professor in 2009. I received my Ph.D. in personality psychology from the University of Michigan, Ann Arbor, in 1998 and completed post-doctoral studies in social psychology at Case Western Reserve University. In 1993, I graduated from the University of Chicago with a B.A. in sociology and psychology and an M.A. in social sciences. A current copy of my true and correct curriculum vitae is attached to this report as Exhibit A. A statement of my compensation for services performed in this case is attached as Exhibit B. A list of all cases in which I have testified as an expert at trial or by deposition during the past four years is attached as Exhibit C.

2.2 Specific Research Focus

11. Much of my research focuses on generational differences – how the period when you were born impacts your personality traits, mental health, and behaviors. Generations exist because cultures change. Just as Japan has a different culture from the U.S., the culture of the 1950s was different from the culture of the 2020s. Traditional theories of generational differences hypothesize that the major world events experienced by each generation shape their worldview. However, major events are only a small part of the picture of why, for example, it was so different to grow up in past decades compared to now. Instead, technology has the most significant impact. For example, adolescents once socialized more in person, but after social media on smartphones became more common, socializing moved mostly online. Technology also changes cultures via secondary forces, including increasing individualism (more focus on the self and less on others) and slower development (taking longer to grow up and longer to grow old).

12. I work with large, nationally representative datasets that survey adolescents every year or every other year. These datasets have two distinct advantages: their large sample size makes analyses more reliable and less prone to random variation, and their representative sampling makes them more generalizable to adolescents as a whole. The Monitoring the Future dataset, for example, has surveyed U.S. 12th graders every year since 1976 and 8th and 10th graders every year since 1991. In the early 2010s sudden increases appeared in loneliness and depressive symptoms, prompting me to explore why they occurred. My research has led me to conclude that there is a causal relationship between the increasing popularity of social media use, particularly on smartphones, and adolescent depression. I have published these findings in over 30 peer-reviewed papers, which are listed on my curriculum vitae attached as Exhibit A. In collaboration with researchers Jonathan Haidt and Zach Rausch, since 2019 I have also maintained open-source literature reviews on trends in adolescent mental health and associations between social media use and adolescent mental health. Other researchers have contributed to these literature reviews, and Meta researchers, for example, have also analyzed the resource. (META3047MDL-019-00034776).

3. Methods

13. In forming the opinions for this report, I relied on my prior research and research from others, including studies referenced in the attached materials considered list, Exhibit D, as well as those cited in the above mentioned open-source literature reviews on trends in adolescent mental health and social media use.

14. In this report, I review four types of research studies investigating the association and potential causal relationship between social media and mental health among adolescents: (1) time series studies, (2) correlational studies, (3) longitudinal studies, and (4) experimental studies.

3.1 Time Series Studies

15. Time series studies examine trends over time in the characteristics and experiences of a population. They usually rely on large nationally representative samples or on statistics (such as the suicide rate) that include the entire population of interest. Time series studies are sometimes called "natural experiments" as they can demonstrate the consequences of changes in the environment. Time series studies can point toward causation if one factor occurs before another. They cannot show causation as definitively as a random-assignment experiment (also known as a randomized-controlled trial), but they usually use considerably larger samples, making them less vulnerable to random variation (i.e. chance).

16. The time series studies discussed in this report rely primarily on datasets that collect nationally representative samples, meaning their demographic profile matches that of the targeted population as a whole. These datasets also have large sample sizes, between 4,000 and 18,800 adolescents a year. I also draw from the Centers for Disease Control and Prevention's (CDC) WISQARS database that records behaviors linked to depression, such as suicide rates and emergency room admissions for self-harm. The WISQARS database compiles data from the National Center for Health Statistics (NCHS) mortality data files, the National Electronic Injury Surveillance System All Injury Program, and the National Violent Death Reporting System (NVDRS). Accordingly, the WISQARS database is one of the most (if not the most) robust data sources documenting causes of adolescent injury and death. The WISQARS database includes Americans of all ages. For emergency department admissions for self-harm behaviors, I present data on 10-19 year old girls. For suicide rates, I present data on 10-19 year old boys and girls.

17. I also analyzed data from the National Survey on Drug Use and Health (NS-DUH), a yearly study commissioned by the U.S. Department of Health and Human Services. Despite its name, the NS-DUH's scope is not limited to drug use. Since the 1970s, the NS-DUH has been designed to, among other goals, determine the rates of depression in the U.S. population as a whole, regardless of interaction with the healthcare system or physician diagnoses. Major depressive episode (MDE) is measured using the criteria of the Diagnostic and Statistical Manual (DSM) of the American Psychiatric Association. The NS-DUH is one of the most robust datasets available on adolescent mental health in the United States and MDEs are one of its key metrics. The NS-DUH is representative of the U.S. population aged 12 years and older. For MDE, I analyzed data on 12-to 17-year-olds.

18. As noted above, I also regularly draw from the Monitoring the Future (MTF) study in my research and do so in this report. MTF surveys a nationally representative sample of 8th, 10th, and 12th graders in the United States every year. Because MTF works with schools, response rates are very high, making the data more representative.

19. Social media is defined somewhat differently from one dataset to another, but is usually referred to as "social networks" or "social media," with examples of specific apps sometimes given. For example, in MTF, adolescents are asked how much time they spend "on social networking sites like Facebook, Twitter, Instagram, etc." None of the studies cited below that measure social media use include streaming services (such as Disney+, Netflix, or Hulu) in the wording of their survey items on social media.

3.2 Correlational Studies

20. Correlational studies examine people's real-life experiences. Correlational studies can show an association between variables. That association could be caused by variable A (social media use) causing variable B (depression), by variable B (depression) causing variable A (social media use), or by a third variable C (sex, race, social class, or other factors) causing both. Although it is true that "correlation is not causation," correlation can point toward possible causation. Correlational studies are a particularly important piece of evidence in assessing causation when randomized controlled trials are infeasible or unethical. Correlational studies also often include a much larger number of participants than randomized controlled trials, making them less vulnerable to random variation in results.

3.3 Longitudinal Studies

21. Longitudinal studies follow the same group of people over time. Longitudinal studies examine whether variable A at Time 1 predicts variable B at Time 2; if so, that indicates there may be a causal relationship between variable A and variable B. A causal event (e.g., exposure) always precedes the effect it causes. This examination of time sequence is a strength of longitudinal studies. However, longitudinal studies on adolescent mental health and social media use vary widely in sample size and in the time interval used between Time 1 and Time 2 (days, months, years).

3.4 Randomized Experimental Studies

22. Random-assignment experimental studies (also known as randomized-controlled trials, or RCTs) involve participants who are randomly assigned to either an experimental or control group, experience a treatment or intervention, and have outcomes measured. This randomized controlled trial design provides a high level of causal evidence. However, experimental studies often rely on much smaller samples than time series or correlational studies, potentially making them vulnerable to random variations in results. In addition, RCTs are often unfeasible or unethical. For example, it is not possible to randomly assign people to be born at different times to create an RCT similar to a time series study. It would be unethical to randomly assign people, especially minors, to spend 8 hours a day using social media to the exclusion of other activities.

3.5 Application of Bradford Hill Criteria

23. Finally, I review the totality of the above evidence for causality between social media use and mental health using the Bradford Hill criteria developed in the 1960s as scientists sought to determine whether cigarette smoking caused lung cancer. The Bradford Hill criteria consist of nine guidelines that are used to determine whether there is a causal association between exposure to a factor and an observed outcome or effect.

4. Detailed discussion of summary of findings

24. Time-series studies show that youth who reached adolescence after the early 2010s have worse mental health than previous generations. No other variable fits the generational trend as completely or as well as social media and smartphone use. Correlational studies (which reveal a dose-response relationship), longitudinal studies (which show a predictive effect), and RCTs also all point toward social media use causing worse mental health.

4.1 Time Series Studies

25. In the early 2010s, symptoms of depression, loneliness, and unhappiness all increased among American adolescents in large, nationally representative surveys (Mojtabai et al., 2016; Keyes et al., 2019; Twenge et al., 2018b, 2019a). Mojtabai et al. (2016) found a statistically significant increase in the prevalence of major depressive episode (MDE) from 2005 (8.7%) to 2014 (11.3%) among 172,495 adolescents ages 12 to 17 in the NSDUH dataset. Between 2011 and 2019, rates of MDE doubled among U.S. adolescents in NS-DUH (see Figure 1; Twenge et al. 2025a).

26. Using data on 1.2 million 8th, 10th, and 12th graders from the Monitoring the Future (MTF) dataset, Keyes et al. (2019) found that depressive symptoms declined slightly from 1991-2011 and then increased from 2011 to 2018, replicating and extending Twenge et al. (2018a), which also examined trends in depressive symptoms in MTF and found the same results. In addition, adolescents' psychological well-being, including happiness, life satisfaction, and self-esteem, declined significantly between 2012 and 2018 among 1.1 million 8th, 10th, and 12th graders in the MTF dataset (Twenge et al., 2018b).

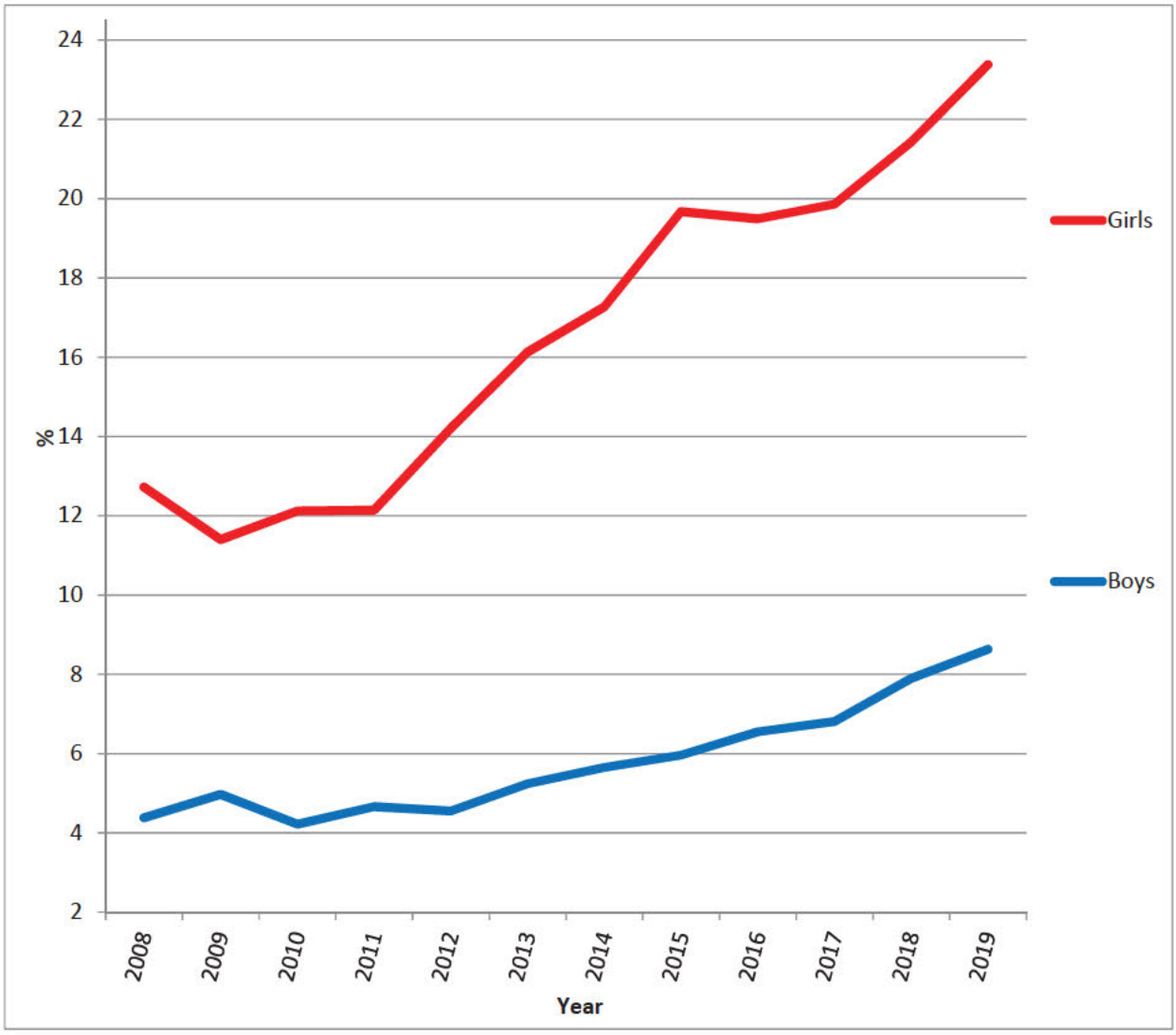

Figure 1: Major depressive episode in the last year, U.S. 12- to 17-year-olds, 2008-2019 Source: National Survey on Drug Use and Health, U.S. Department of Health and Human Services..

27. Behaviors linked to depression, such as self-harm, also increased among adolescents. According to the WISQARS dataset kept by the CDC, emergency room admissions for self-harm nearly doubled among 15- to 19-year-old girls and more than tripled among 10- to 14-year-old girls between 2009 and 2019. Rates of self-harm increased further during the pandemic years. By 2023, self-harm rates had returned to 2019 levels among 15- to 19-year-olds, but self-harm rates remained 55% elevated above 2019 rates among 10- to 14-year-old girls, with rates quintupling between 2009 and 2023 (see Figure 2).

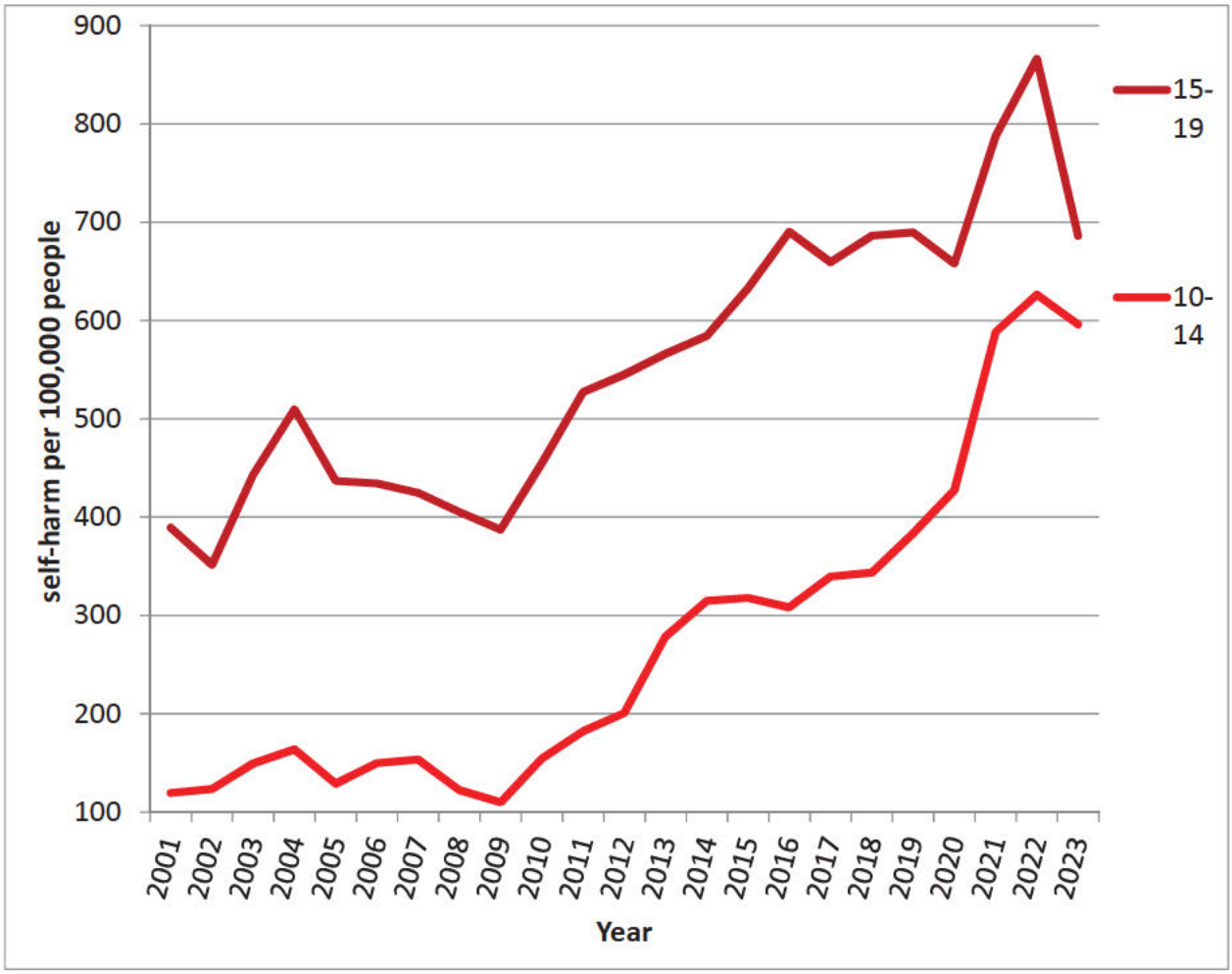

Figure 2: Emergency department admissions for self-harm behaviors, U.S. girls and young women, 2001-2023
Source: WISQARS database, Centers for Disease Control

28. Rates of emergency room admissions and hospitalization for suicidal thoughts or suicide attempts among U.S. adolescents nearly doubled between 2007 and 2015 according to large studies of hospital records (Burstein et al., 2019; Plemmons et al., 2018). For example, Burstein et al. analyzed the National Hospital Ambulatory Medical Care Survey, a nationally representative dataset gathered by the CDC. The estimated number of annual visits for suicidal thoughts and suicide attempts among children 17 and younger increased from 580,000 in 2007 to 1.12 million in 2015. Plemmons et al. analyzed administrative billing data drawn from the Pediatric Health Information System database, finding that hospital visits for suicidal thoughts and suicide attempts nearly doubled among U.S. children and adolescents between 2008 and 2015.

29. Spiller et al. (2019) conducted a retrospective review of 1.6 million intentional self-poisoning cases of 10- to 24-year-olds reported to the National Poison Data System from U.S. poison centers between 2000 and 2018. (Poison is one of the most common

means used by adolescents in suicide attempts). Spiller et al. found that self-poisoning cases increased significantly beginning in the early 2010s, especially among girls (Spiller et al., 2019).

30. Suicide rates also skyrocketed among American adolescents in the early 2010s (see Figure 3). The suicide rate for adolescent girls more than doubled between 2007 and 2023. Among boys, the suicide rate jumped 74% between 2007 and 2017 and then moderated back to 2016 levels, which were still 43% higher than in 2007. If the suicide rate had stayed at its 2007 low, 12,472 more American 10- to 19-year-olds would be alive today, an average of almost 800 excess suicide deaths a year.

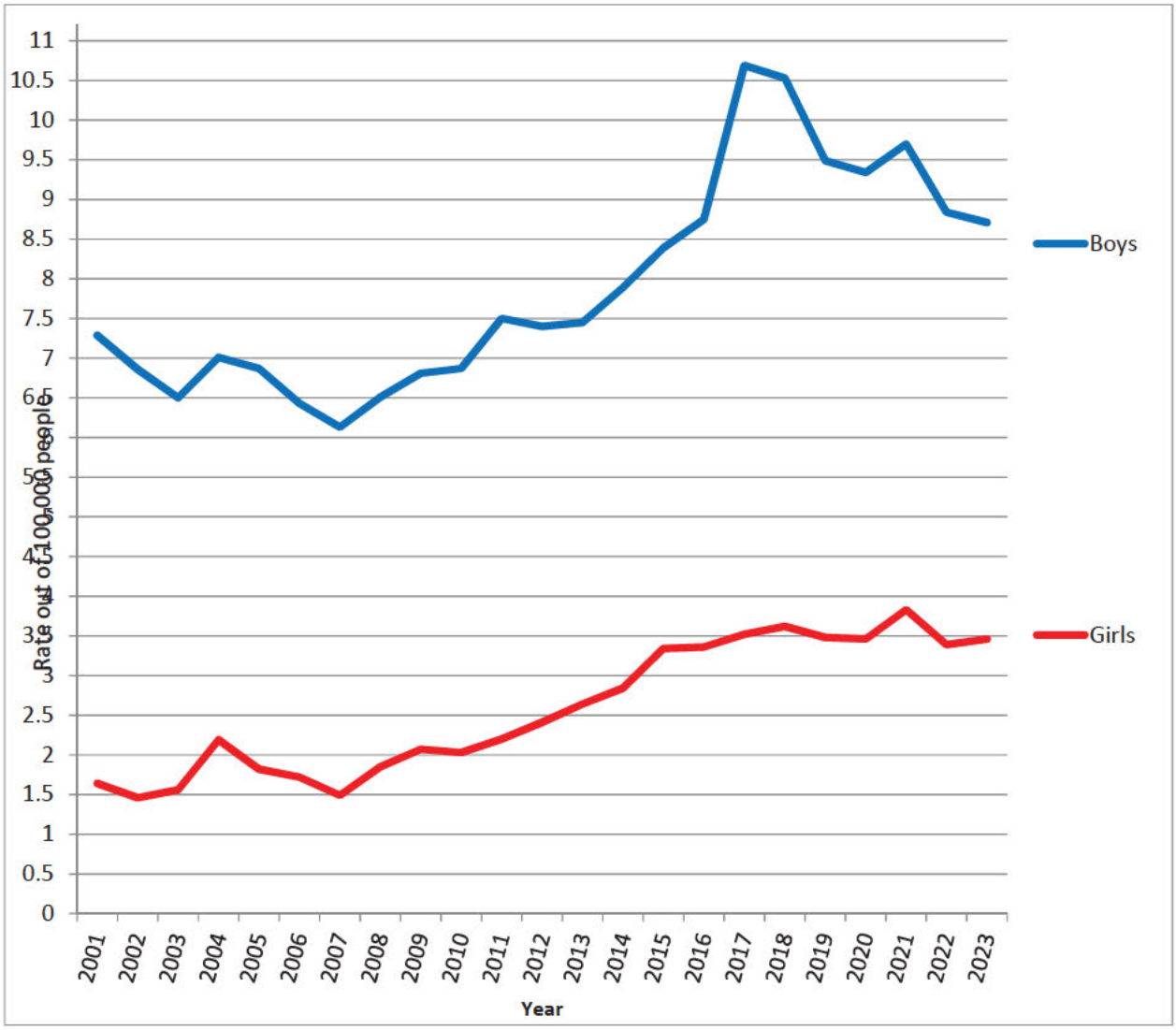

Figure 3: Suicide rate of U.S. 10- to 19-year-olds, 2001-2023
Source: WISQARS database, Centers for Disease Control

31. These trends in adolescent mental health are best understood in the context of changes over many decades. To my knowledge, no dataset has consistently measured adolescent mental health from the mid-20th century to the present. Taken together, however,

several sources can provide a view of past trends. Mental health issues among adolescents and young adults grew steadily worse between the 1950s and the early 1990s, likely due to factors such as family instability, increases in the crime rate, and an emphasis on extrinsic goals (e.g., Klerman & Weissman, 1989; Lewinsohn et al., 1993; Newsom et al., 2003; Twenge, 2000). Between the early 1990s and the late 2000s, however, depressive symptoms, suicidal thoughts, and suicide rates declined as the crime rate fell, economic conditions improved, and anti-depressant medications became more commonly used (Keyes et al., 2019; Twenge et al., 2018a; see Figure 4 for depressive symptoms).

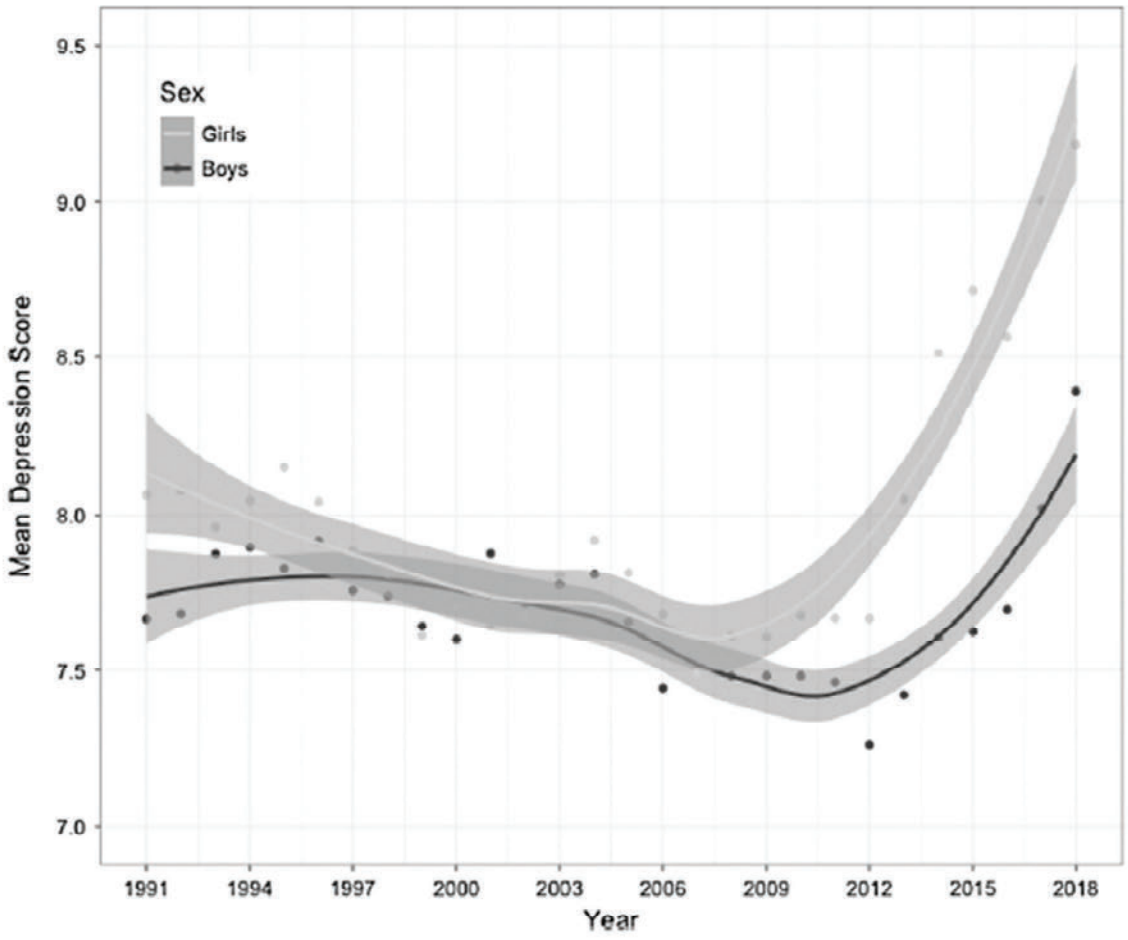

Figure 4: Depressive symptoms among U.S. adolescents, 1991-2018.
Source: Keyes et al. (2019)

32. Although milder symptoms of depression (such as psychosomatic symptoms and feeling overwhelmed) increased between the early 1990s and the late 2000s among adolescents and young adults, more overt and severe indicators (self-reported depression, suicidal thoughts, making a suicide plan, and suicide rates) declined over that time among adolescents (Twenge, 2015, and see Figure 5). Then after 2010, depressive symptoms, suicidal thoughts, self-harm, and suicide rates increased, as shown earlier.

Figure 5: Percent of U.S. high school students who seriously considered attempting suicide or who made a plan about how they would attempt suicide, 1993-2021
Source: Youth Risk Behavior Surveillance Survey, Centers for Disease Control

4.1.1 Explanations for the adolescent mental health crisis

33. I have considered many explanations for the observed population-level rise in depression, self-harm, and suicide among adolescents. The time series studies provide evidence supporting the conclusion that the increase in social media use is a contributor to the adolescent mental health crisis.

34. **Increased social media use.** The early 2010s was a key time for technological change. Adolescent smartphone ownership grew from 23% in 2011 to 37% in 2013, reaching 73% by 2015 (Lenhart, 2015; Madden et al., 2013). By 2024, 95% of teens had access to a smartphone (Faverio & Sidoti, 2024). Unlike computers, smartphones allow constant access to social media apps. Smartphones with front-facing cameras (which make it easier to

take selfies) were introduced in 2010. Facebook bought Instagram – dramatically increasing its user base – in 2012. In 2005-09, half of U.S. 12th graders reported using social media almost every day; by 2016, 82% did (Twenge et al., 2019b). Adolescents in 2013 spent less than 1.5 hours a day on social media (Twenge et al., 2019b); by 2023, they spent 4.8 hours a day (Rothwell, 2023).

35. It is highly implausible that increases in adolescent depression caused the increasing popularity of smartphones and social media, as opposed to the increasing popularity of smartphones and social media causing increases in adolescent depression. The time series studies show that smartphone and social media use became increasingly widespread first, and then adolescent depression increased (Twenge et al., 2018b).

36. This may have occurred partially because social media displaced time that was once spent on other activities more beneficial for mental health. For example, sleep deprivation also increased beginning around 2012 (Twenge et al., 2017). As shown in Figure 6, the number of adolescents getting inadequate sleep increased between 2011 and 2015 across two surveys. Sleep is essential for the healthy development of adolescents. Social media, more than TV or gaming, is linked to shorter sleep, more mid-sleep awakenings, and longer time to fall asleep (Hisler et al., 2020).

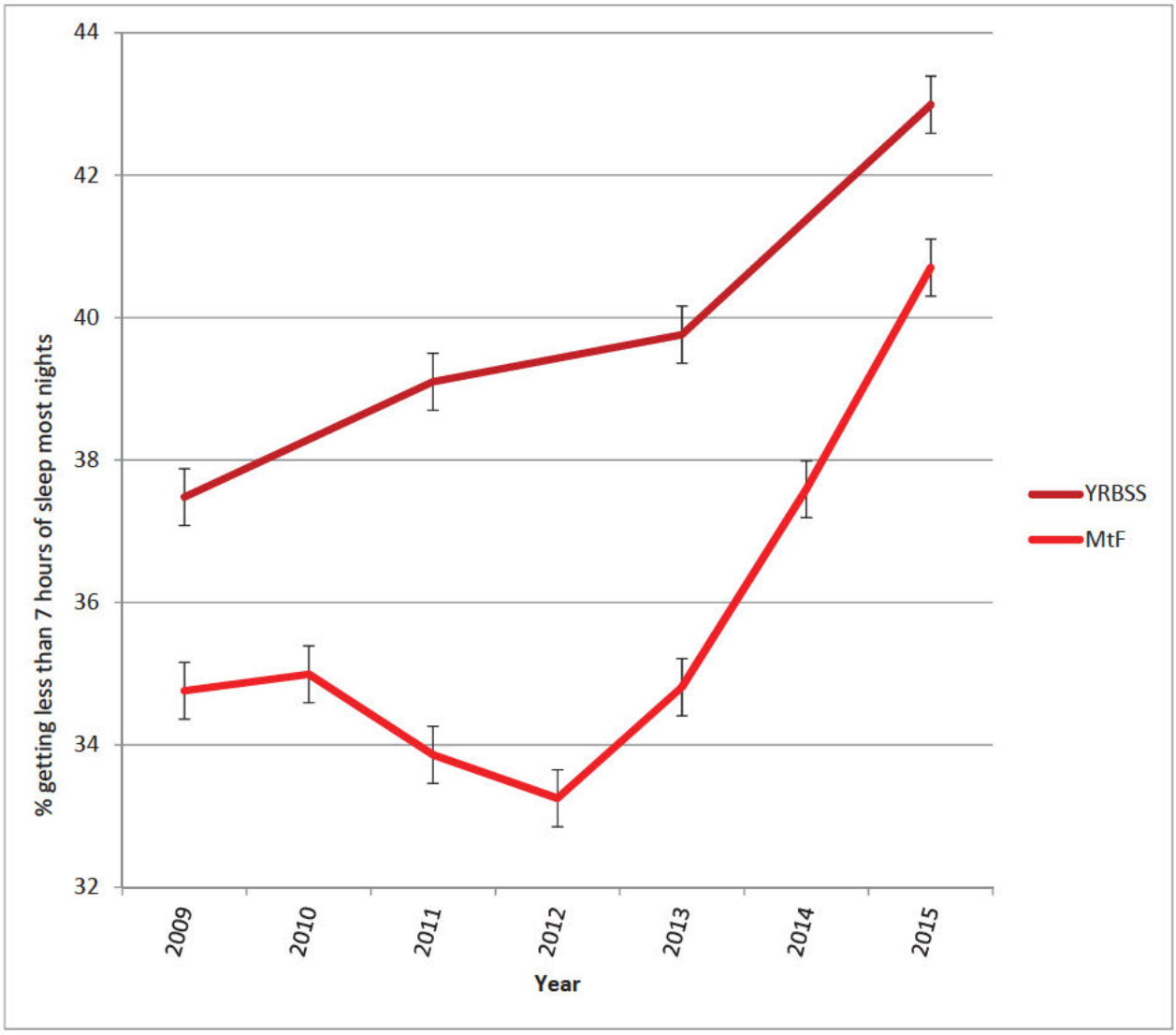

Figure 6: Percent of adolescents getting fewer than 7 hours of sleep on most nights, 2009-2015. Source: Twenge et al. (2017) Note: YRBSS = Youth Risk Behavior Surveillance System, CDC. MtF = Monitoring the Future.

37. The effects of social media operate at the group level, not just the individual level (Twenge et al., 2019c). Even an adolescent who does not use social media is impacted when most of their peers use social media: They may feel left out and excluded from some interactions, and it will be more difficult to convince friends to interact in person if communicating via social media is the norm. This is a strength of the time series studies: They capture the impact of social media at the group level as a natural experiment.

38. Another time series study examined another natural experiment: The staggered rollout of Facebook on U.S. college campuses. After Facebook was introduced on a campus, students' depression increased, as did their use of mental health services (Braghieri et al., 2021).

39. Twenge et al. (2018b) employed Granger causality analyses, a statistical hypothesis test introduced by an economist in 1969, to examine the order of the effects. A Granger causality test examines the ability of one time series to predict another. The study demonstrated that U.S. smartphone ownership and internet use (one time series) predicted adolescents' unhappiness (another time series) one year later more strongly than unhappiness predicted smartphone adoption and internet use one year later. Thus, smartphone ownership and greater internet use increased first, before the increase in adolescent unhappiness. This shows a causal pathway from smartphone adoption and internet use to unhappiness among adolescents (Twenge et al., 2018b).

40. These trends appear internationally as well. Several studies have found increases in poor mental health among adolescents in many countries around the world beginning after 2012. Most of this evidence is from Europe, Latin America, and English-speaking countries such as Canada, the UK, and New Zealand (Boer et al., 2023; Krokstad et al., 2022; Patalay & Gage, 2019; Schrijvers et al., 2024; Twenge et al., 2021). Adolescent loneliness and psychological distress increased the most in countries with the largest increases in smartphone access (Boer et al., 2023; Twenge et al., 2021). In addition, diagnosis and treatment for self-harm behaviors and other mental health issues have skyrocketed among adolescents in the UK; thus, there is behavioral, not just self-reported, evidence for declining mental health (Cybulski et al., 2021; Ward et al., 2025). These international results mean the cause of the increase in adolescent depression cannot be something unique to the U.S. Instead, it must be something impacting adolescents in many different countries.

41. While a few studies have not found increases in poor mental health among adolescents since 2010 (e.g., Vuorre & Przybylski, 2023, 2024a, b), these studies are exceptions and rely on two sources that have been shown to be unreliable (Rausch, 2024). Study 2 in Vuorre and Przybylski (2024a) relies on the Global Burden of Disease (GBD) study, which uses *estimates* of mental health indicators, not actual data on the prevalence of depression, self-harm, and suicide. Vuorre and Przybylski admit that "GBD estimates are not observed data." In fact, observed data completely contradicts the GBD estimates. For example, the GBD estimates have teen depression rates staying stable between 2004 and 2019, when actual observed data shows them more than doubling (see Figure 1). Similarly, the GBD estimates increases in self-harm and suicide that are only about one-fifth the size of the increases in actual data.

42. Study 1 in Vuorre and Przybylski (2024a) uses the Gallup World Poll, which is one of the only studies of well-being that does not show a mental health decline among young people. The sample size for young women – the group that shows the largest changes in other datasets – is extremely small in the Gallup World Poll. In 2021, for example, there were only 33 women ages 15 to 25 who completed the Gallup World Poll in the U.S (Blanchflower, 2024). Vuorre & Przybylski (2023) and Vuorre & Przybylski (2024b) also used Gallup World Poll data. As there is little to no variation in internet access in higher-income countries in their sample, their conclusions about the effects of internet access on mental health are unreliable. For example, in the U.S. Gallup World Poll data, among the 313 people under age 25, all of them had used the internet – there was no variation at all, making it impossible to draw conclusions about internet access and well-being (Blanchflower, 2024).

4.1.2 Other Suggested Causes

43. When assessing possible causes of the increases in poor mental health, it is important to focus on population-level factors rather than individual factors. Time series studies are not concerned with all of the possible causes of poor mental health among individuals; instead, they must concentrate on possible causes that appear among most of the population. Thus, factors that impact only a small number of individuals are unlikely to explain time-series trends. For example, a natural disaster affecting people in one area is unlikely to explain population-level changes in mental health.

44. None of the potential alternative causes often suggested fit the data as well as the increasing popularity of smartphones and social media (Twenge, 2023b), as explained below.

45. **Greater willingness to admit to symptoms or seek help**. To my knowledge, no study has demonstrated an increase in adolescents' willingness to disclose symptoms of mental health disorders after the early 2010s. Even if we accept the unproved premise that willingness to admit to symptoms has steadily increased, it still cannot explain the trends. To do so, willingness to admit to symptoms would have had to decline between the early 1990s and 2011 and then suddenly increase after the early 2010s (as in Figure 4 of self-reported symptoms of depression). There is no evidence for such a curvilinear pattern. In addition, surveys such as MTF and NS-DUH are anonymous and self-administered, minimizing the possibility that the results are influenced by stigma or willingness to admit to mental health issues. Greater willingness to seek help or greater access to mental health care also cannot explain the trends. The NS-DUH dataset measuring the prevalence of MDE (Figure 1) obtains a cross-section of the U.S. population, not just those who seek help or receive mental health care. The MTF dataset, which shows increases in depressive symptoms, unhappiness, and loneliness, also relies on a cross-section of the population. Thus, both datasets are designed to capture a random sample of individuals representative of the entire U.S. population. Neither source draws from mental health services utilization data and therefore cannot be influenced by willingness to seek help or use mental health services. Thus the increase in poor mental health cannot be attributed to a greater willingness to admit symptoms, a greater willingness to seek help for mental health issues, or an increased ability to receive care. Further, objectively measured behaviors that do not rely on self-reporting, such as emergency room admissions for self-harm (Figure 2) and completed suicides (Figure 3) reveal a trend consistent with self-reported mental health surveys. Thus, the increases cannot merely be due to changes in self-reporting, given that they extend to behaviors.

46. **Physicians' willingness to diagnose and diagnostic coding**. The evidence for the rise in adolescent depression presented in section 4.1 is from nationally representative surveys outside of health care settings. These surveys do not rely on physician diagnoses or physician screening. Thus, factors such as physicians' willingness to diagnose depression, greater physician screening for depression, or changes in diagnostic coding for depression cannot explain the increases in depression or depressive symptoms in these sources. Corredor-Waldron and Currie (2024) argue that a change in diagnostic coding in 2015-16 is the cause of the increase in one statistic, emergency room admissions for self-harm, citing data from one U.S. state (New Jersey). However, as shown previously, the early 2010s is the inflection

point, not 2015-16 (see Figures 2 and 3). Self-harm rates increased steadily both before and after 2015-16, contradicting the idea that a coding change in 2015-16 is responsible for the observed effects on adolescent mental health.

47. **The Great Recession.** The rise in adolescent depression is completely misaligned with economic trends; in fact, the U.S. economy was steadily improving as adolescent depression rose. For example, unemployment declined consistently as adolescent depression increased between 2011 and 2019 (Twenge et al. 2018b). That is exactly the opposite of what one would expect if an economic downturn were the cause of increased teen depression. Social media use, however, increased in lockstep with depression rates.

48. **School shootings.** School shootings became prevalent beginning in the late 1990s, a time when adolescent depression was declining (e.g., Keyes et al., 2019). Thus, school shootings are unlikely to be the sole or primary factor in declining adolescent mental health in the 2010s. In addition, if the primary cause of increases in depression were school shootings, fears of school shootings, or school lockdown drills, increases in mental health issues would not appear in countries where school shootings occur at considerably lower rates. However, they do. For example, the number of young Australians with high levels of psychological distress skyrocketed between 2012 and 2019, in a very similar pattern to the U.S. data (see Figure 7), despite significantly fewer instances of school shootings.

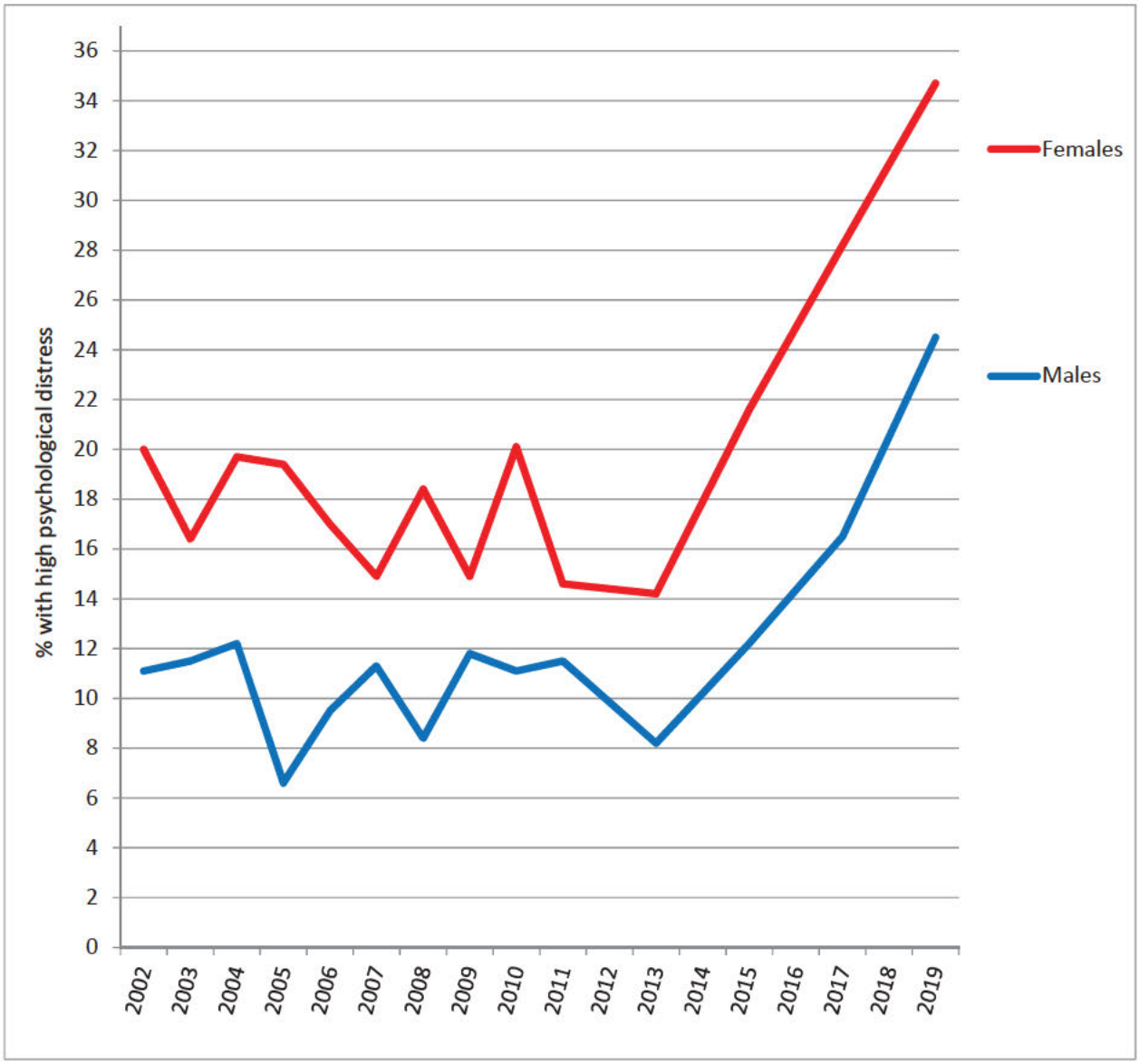

Figure 7: Australians ages 16 to 24 with high or very high levels of psychological distress, by gender, 2002-2019
Source: Data tables for *Australia's Health 2022: Data insights*. Australian Government.
NOTE: Psychological distress was measured using the K10, a validated 10-item measure of symptoms of anxiety and depression.

49. In addition, self-harm behaviors increased among Australian adolescent girls beginning in the early 2010s (see Figure 8). Self-harm also increased among adolescent boys, though their base rate was lower. Hospital admissions for mental health concerns also increased among adolescents in England, another country where school shootings are uncommon (Ward et al., 2025).

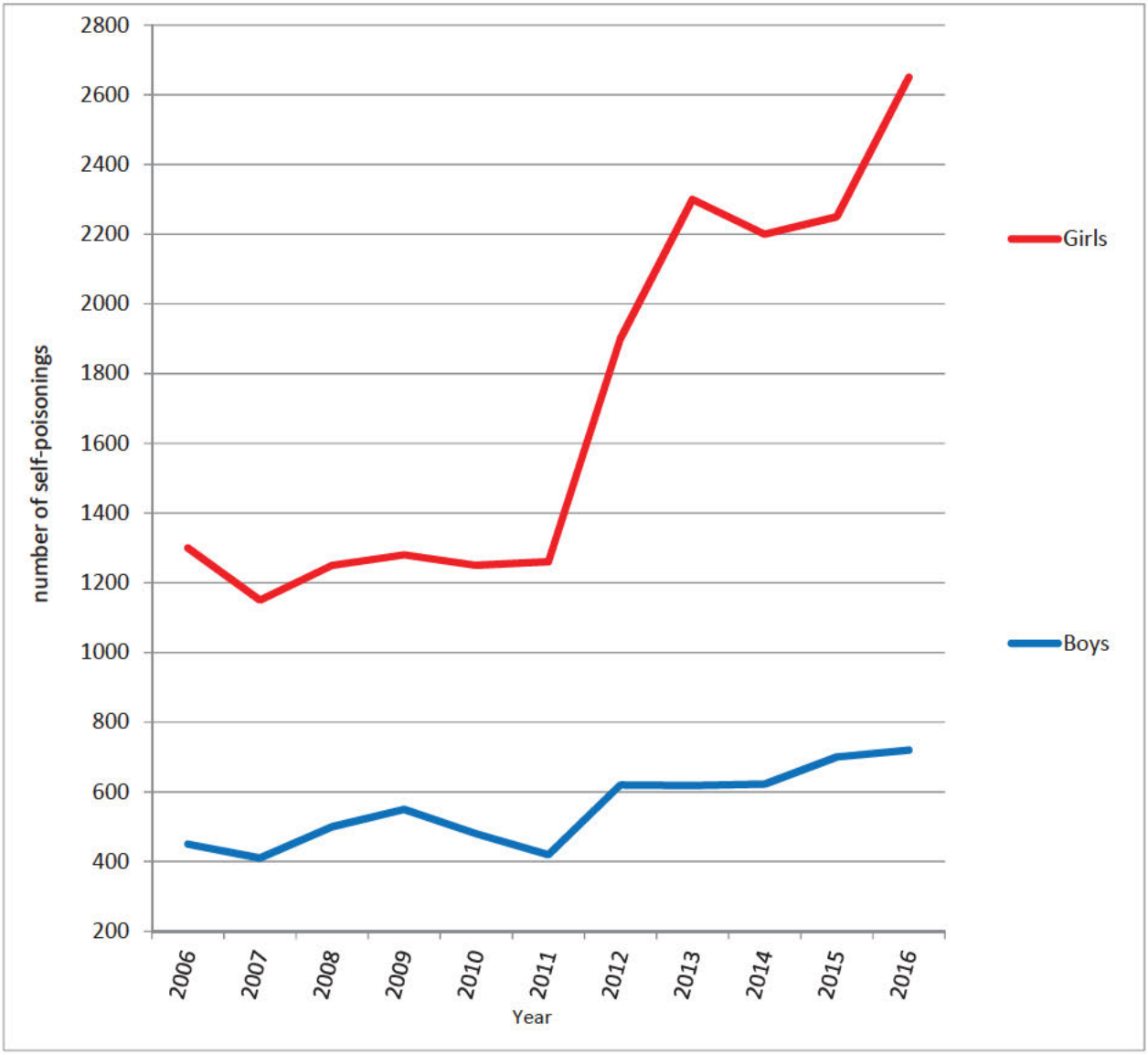

Figure 8: Intentional self-poisonings among 15- to 19-year-olds, Australia, 2006-2016
Source: Cairns et al. (2019) analysis of data on calls to Poison Information Centers in New South Wales and Victoria, Australia.

50. **Ownership of handguns**. The presence of a handgun in a household is a risk factor for suicide (Swanson et al., 2021). Thus, if handgun ownership increased after 2008, that might help explain the rise in adolescent suicide after 2008. However, Gutierrez et al. (2022), Figure C, shows that handgun ownership among White households in the U.S. did not change significantly between 2008 and 2018 (see Figure 8a; the authors did not include a similar graph for Black households). Firearm suicides and firearm ownership in Black households with adolescent children were not linked, and rates of handgun ownership among White households with children ages 15-19 did not change between 2008 and 2018 (see the lowest line in Figure 8b; note that this analysis is based on a small sample size and thus should be interpreted with caution). Thus, handgun ownership cannot have caused the rise in adolescent suicide 2008-2018 as it did not increase during this time period.

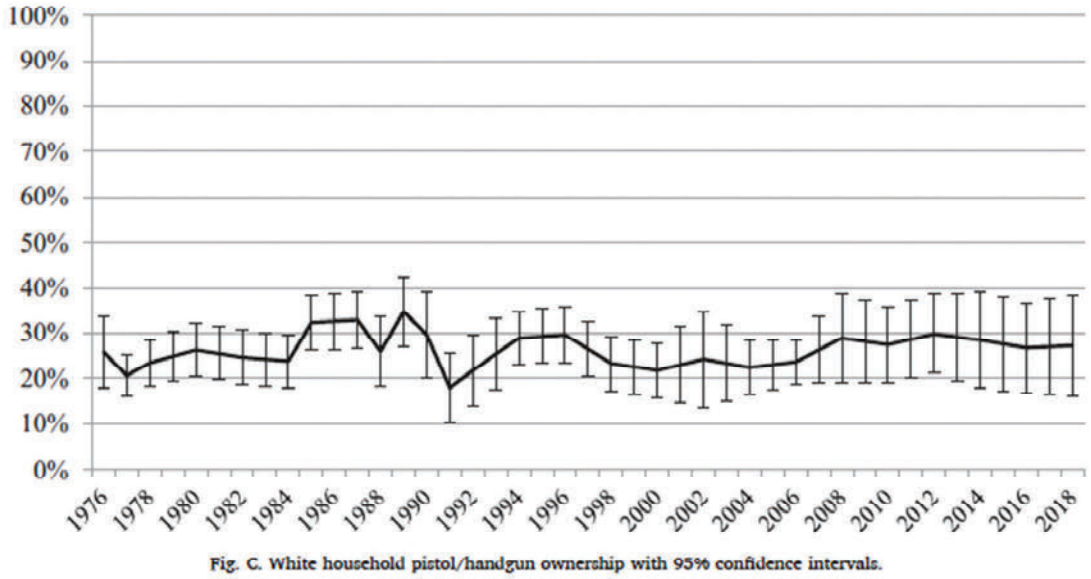

Figure 8a: Handgun ownership among White households. Source: General Social Survey and Gutierrez et al. (2022). Note: Vertical bars are error bars; if error bars overlap, numbers are not significantly different from each other.

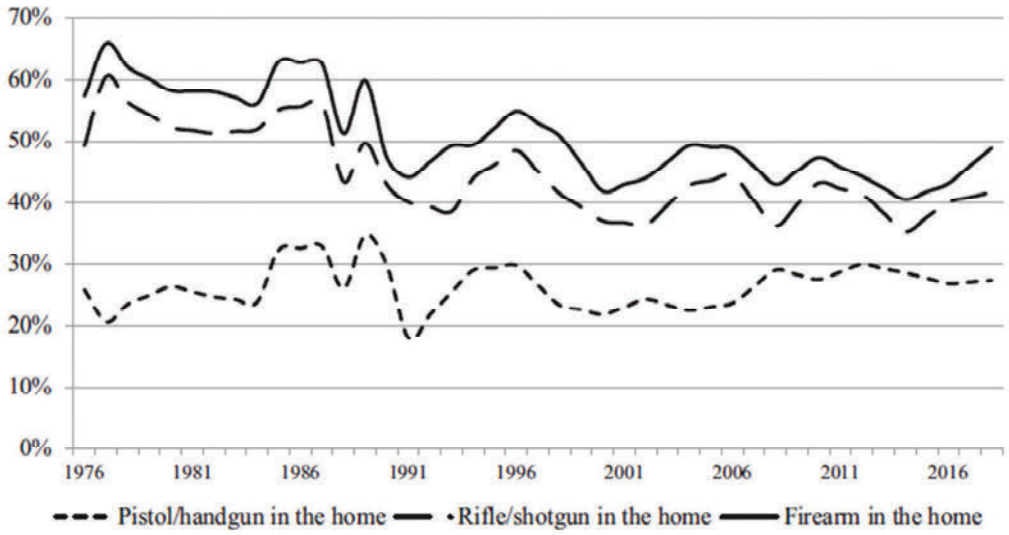

Figure 8b: Firearm ownership and type of firearm among White households with adolescent children aged 15-19 years. Source: General Social Survey and Gutierrez et al. (2022)

51. **The opioid epidemic.** Similarly, increases in poor mental health in countries other than the U.S. also argue against the opioid epidemic as a primary cause. As noted above, trends in American adolescent mental health are mirrored in Australia (see Figures 7 and

8) and the UK. However, drug-related deaths are considerably less in these countries (Gumas & Baumgartner, 2023). The use of the opioid Oxycontin declined among U.S. 10th graders at the time depression was increasing; it was 3.9% in 2011, 2.0% in 2019, and only .4% in 2023 (Miech et al., 2024, Table D-19). In addition, the increase in poor mental health among young adults is similar in states with low versus high rates of midlife mortality, much of which is due to opioid deaths (Twenge, 2024b). Thus, the opioid epidemic cannot explain the increase in adolescent depression.

52. **Climate change.** Although climate change is certainly a concern, the usual response of young people to a crisis is energy and activism, not depression (Haidt, 2024). In addition, if climate change were a primary cause of the increases in depression and self-harm, the largest increases should appear among young adults and older teens, who are more likely to be politically and socially aware. Instead, the largest increases are among children and younger adolescents (for example, the increases in self-harm are considerably larger among 10- to 14-year-olds than among 15- to 19-year-olds; see Figure 2). Climate change also cannot explain why loneliness increased among adolescents after the early 2010s (Twenge et al., 2019c, 2021). In contrast, the profound shifts in how adolescents socialize, with more time on social media and less time with friends in person, can more easily explain a rise in loneliness. Adolescents who are high in social media use and low in in-person social interactions with friends report the highest levels of loneliness (Twenge et al., 2019c).

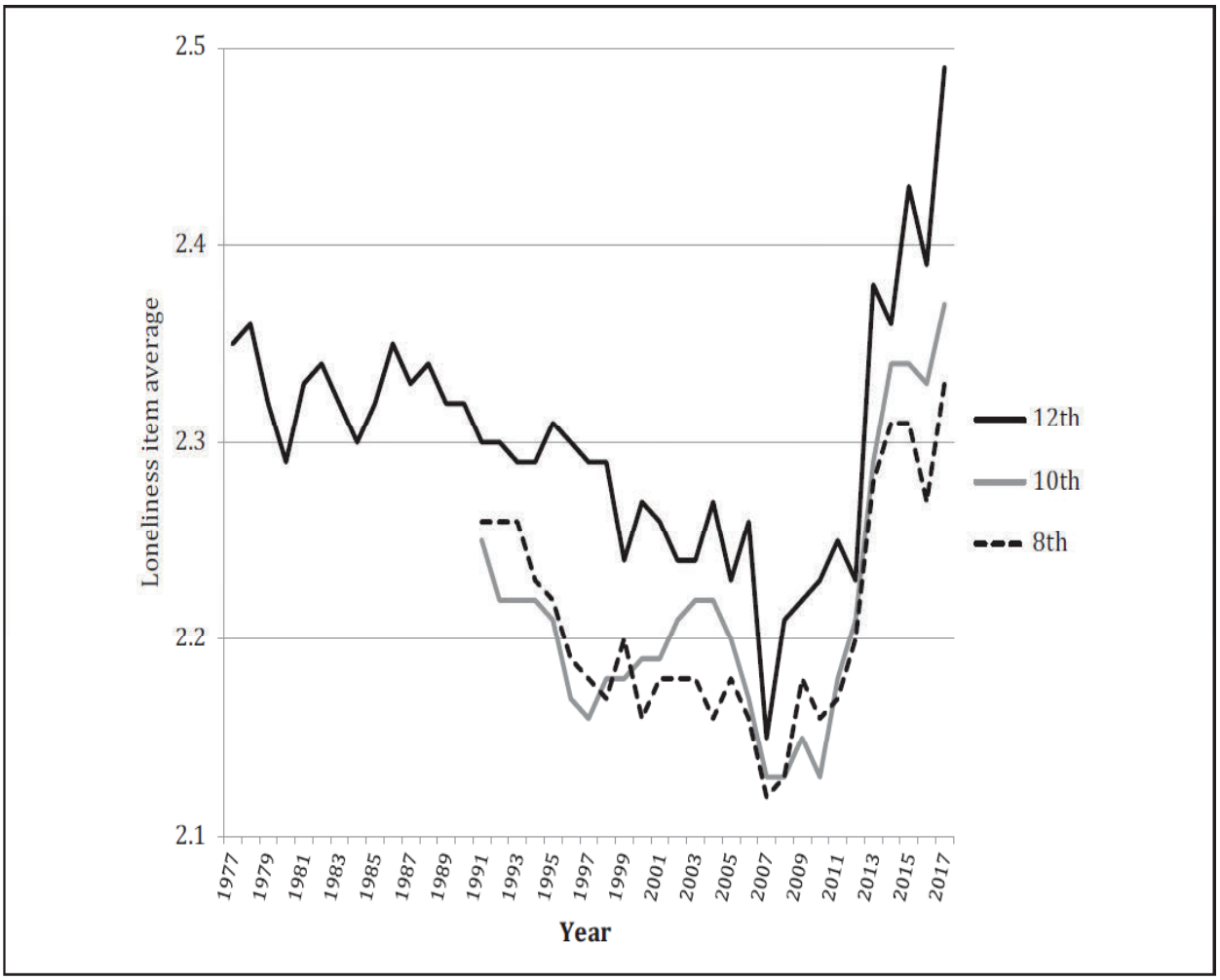

Figure 9: Mean loneliness U.S. 8th, 10th, and 12th graders, 1977-2017
Source: Twenge et al. (2019c)

53. **Academic pressure.** This theory suggests that more adolescents are depressed because they are spending more time on homework and experience more academic pressure. However, homework time among U.S. 8th and 10th graders declined from 2011 to 2023 (Twenge, 2024d). The number of adolescents who say there is too much competition for grades at their school has also declined (Twenge, 2023a). Thus, since homework time and academic pressure are down, they cannot explain the rise in adolescent depression.

54. **Parents are more depressed.** Perhaps more adolescents are depressed because more of their parents are depressed. This theory recently received attention in the media because of the U.S. Surgeon General's Advisory on the Mental Health and Well-Being of Parents (Murthy, 2024). However, the large national datasets do not support the idea that depression has increased among parents; instead, parental depression rates are historically low or stable (Twenge, 2024e). For example, depression rates were unchanged among U.S. adults ages 26 and over between 2011 and 2017 (Twenge et al., 2021). More specifically, depression rates

were unchanged among parents ages 35 to 64 – the ages most likely to have adolescent children – between 2011 and 2022 (Twenge, 2024e).

55. **COVID-19 pandemic and lockdowns.** The increases in depression, self-harm, and suicide among adolescents began 8 to 12 years before the COVID-19 pandemic began in 2020 (see Figures 1-3). Thus, the pandemic and lockdowns cannot be the cause of the increases in depression, self-harm, and suicide occurring between 2008 and 2019. The pandemic did appear to cause an additional rise in depression that then partially resolved after more pandemic restrictions lifted in 2022 and 2023, but those changes were small compared to the large increases before COVID that coincide with the rise of social media and smartphones (Twenge, 2025b).

56. **Children and teens have less independence.** Some have argued that adolescent mental well-being worsened because children and teens now have less independence (Gray et al., 2023). However, declines in adolescent independence (e.g., having a driver's license, going out with friends, dating) began in the 1990s and early 2000s, years when adolescent depression did not change much (Twenge, 2023b; Twenge & Park, 2019). Adolescent depression only began to rise when social media on smartphones became increasingly popular in the early 2010s (see Figure 1). Adolescent independence continued to decline during that time, with the trends reinforcing each other (Twenge & Park, 2019). For example, with teens spending more time using social media, fewer may have felt the need to get their driver's license or go out. Thus, the decline in adolescent independence was not enough to cause teen depression to rise, but it may have played a role once social media reduced the need for independence, resulting in adolescents spending less time with friends in person.

57. **Demographic changes.** The U.S. population has become more racially and ethnically diverse over the years. If, for example, Black and Hispanic teens were more likely to experience mental health issues and their share of the population rose, that could cause increases in the rate of mental health issues in the population average. If such demographic changes were the primary cause, we would expect to see no or only very small changes in mental health issues over the years *within* ethnic or racial groups. However, that is not the case: Symptoms of depression rose among White, Hispanic, and Black teens in a very similar pattern (Twenge, 2024c; Twenge et al., 2018a). Demographic changes are thus not the cause.

* * *

58. Thus, among the potential factors that have been cited above, the rise of social media on smartphones in the early 2010s is the most plausible cause of the adolescent mental health crisis. This trend had a broad impact on adolescents' day to day lives, radically changing the way they spent their time outside of school. No other cause fits the data as well, or had as big of an impact, as the rise of these technologies.

59. In fact, that was the conclusion of a focus group of adolescent girls convened by Meta as part of its internal research (META3047MDL-003-00109173 at -00109196-97). "Teens blame Instagram for increases in the rate of anxiety and depression among teens. This reaction was unprompted and consistent across all groups," the report noted. "Constant comparison on Instagram is 'the reason' why there are higher levels of anxiety and

depression in young people … young people openly attribute their increased level of anxiety and depression to Instagram." A UK girl interviewed by Meta said, "The reason why our generation is so messed up and has higher anxiety and depression than our parents is because we have to deal with social media. Everyone feels like they have to be perfect." Teens cited a variety of reasons for the connection between Instagram use and depression in the report, including the need for validation through likes and followers, pressure to match the body shapes of influencers, over-sexualization of girls, and inappropriate advertisements (Wells et al., 2021).

60. Overall, the time series data strongly supports the conclusion that changes in adolescents' technology use, including increased use of social media, is a primary cause of the rise in adolescent depression, anxiety, loneliness, self-harm, and suicide.

4.2 Correlational Studies

61. Correlational studies can determine whether adolescents who spend more time on social media are more – or less – likely to be depressed than those who spend less time.

62. Correlational studies have found that the more hours a day an adolescent spends on social media, the more likely they are to be depressed or unhappy. A meta-analysis of 21 correlational studies and five longitudinal studies found that more time spent on social media was significantly associated with a higher risk of depressive symptoms. This association was particularly strong among adolescent girls. The meta-analysis found that the risk of depression increased by 13% with each additional hour of social media use among adolescents (Liu et al., 2022). Thus, an increase from no use of social media to 7 hours a day was associated with a 91% increase in depression rates.

63. The open-source literature reviews mentioned above include all correlational studies my collaborators and I could locate (97 studies as of April 2025) and nearly all show that more time on social media is linked to more depression, unhappiness, low life satisfaction, or low psychological well-being (Haidt et al., 2025).

64. Kelly et al. (2019) is an example of such a correlational analysis. The paper used the Millennium Cohort Study, a large nationally representative sample from the U.K. In 2015, when its participants were 14 to 15 years old, the study asked them how many hours a day they spent using social media. They also answered 13 questions on a validated scale (a vigorously tested survey instrument) measuring symptoms of depression; teens who scored above a cutoff level were classified as having clinically relevant depression. The results showed that girls who were heavy users of social media were three times more likely to be depressed as non-users, and boys were twice as likely (Kelly et al., 2019; see Figure 10).

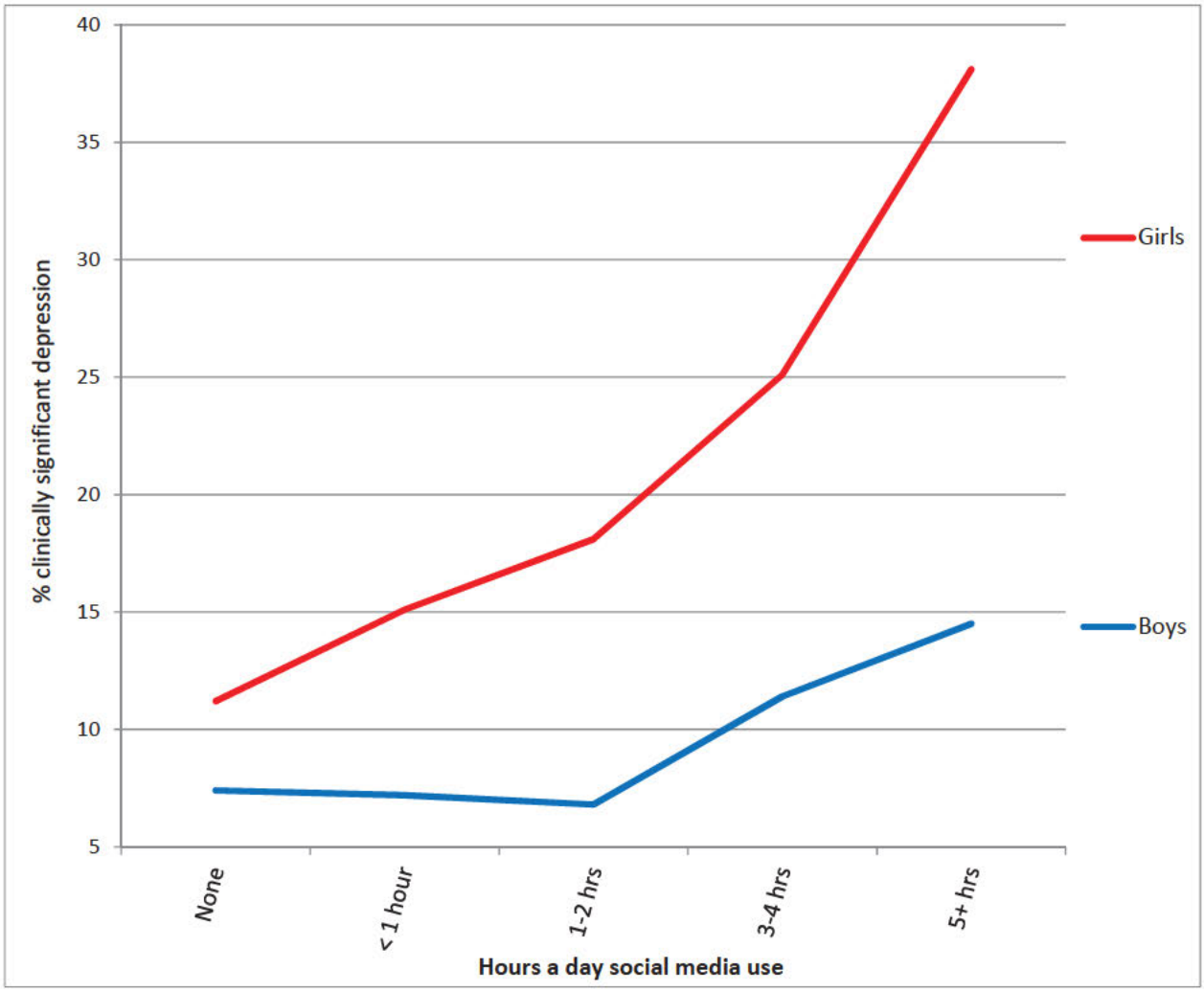

Figure 10: Hours of social media use and depression, U.K. teens, by gender
Source: Millennium Cohort Study. Analyses by Kelly et al. (2019)

65. Kelly et al. found that depression steadily increased as social media use increased in a dose-response manner, particularly among girls. Thus, high levels of social media use are associated with depression more than low levels of social media use. For boys, elevated risk did not appear until their social media use averaged 3 or more hours per day; for girls elevated risk began to appear at less than one hour per day and increased from there (Kelly et al., 2019).

66. Kelly et al. controlled for a number of possible third variables, including family income, family structure, and age. The analyses also controlled for symptoms of depression at age 11. The study's accounting for pre-existing depression symptoms means the observed association was not caused by depressed teens spending more time on social media. In other words, the researchers designed their analysis to eliminate the possibility of reverse causation (Kelly et al., 2019).

67. I have also conducted correlational analyses using data from the Millennium Cohort Study. In my research, I focused on self-harm behavior. Respondents were asked if, in the last year, they had ever hurt themselves on purpose. Girls who were heavy users of social media (greater than 5 hours per day) were twice as likely to have self-harmed than non-users (less than 1 hour per day), and boys who were heavy users were nearly twice as likely (Twenge & Farley, 2020; see Figure 11). Social media use was more strongly related to self-harm than TV watching or gaming. These analyses controlled for family income, family structure, child's ethnicity, child's age, parent educational attainment, parent employment, number of siblings, whether the child had a long-standing illness, and parent verbal intelligence (Twenge & Farley, 2020; Figure 11). That rules out these factors as confounding variables.

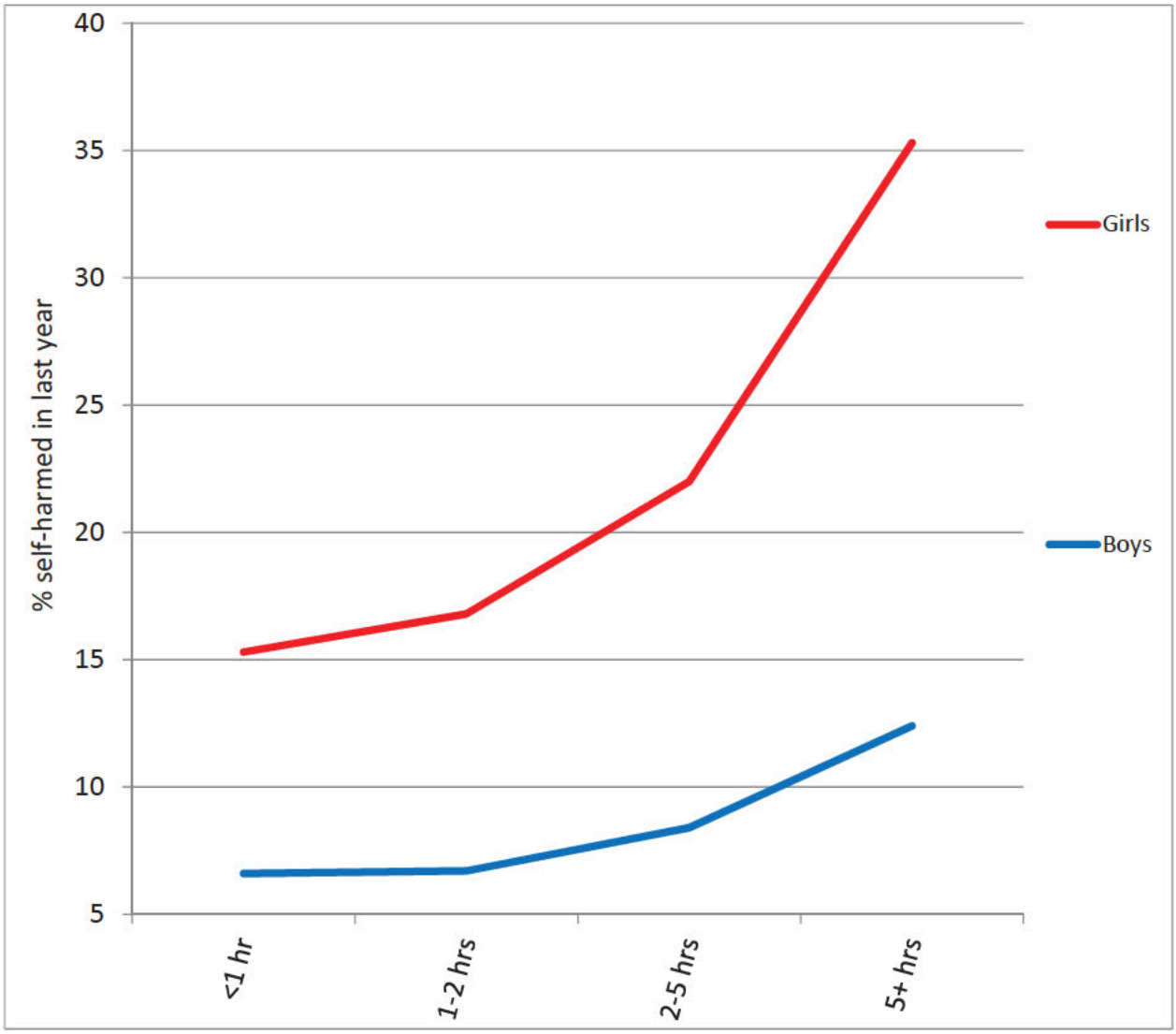

Figure 11: Hours per day of social media use and self-harm behaviors, UK teens, by gender
Source: Millennium Cohort Study. Analyses by Twenge & Farley (2020)

68. I also performed correlational analysis on the Monitoring the Future (MTF) dataset, discussed above. Beginning in 2013, the survey added a question gauging hours per day of social media use. Teens, especially girls, who spent more hours a day on social media

were more likely to be unhappy. In my analysis, I controlled for race, grade, and mother's education level, thus ruling out these factors as third variables (Twenge & Martin, 2020; see Figure 12).

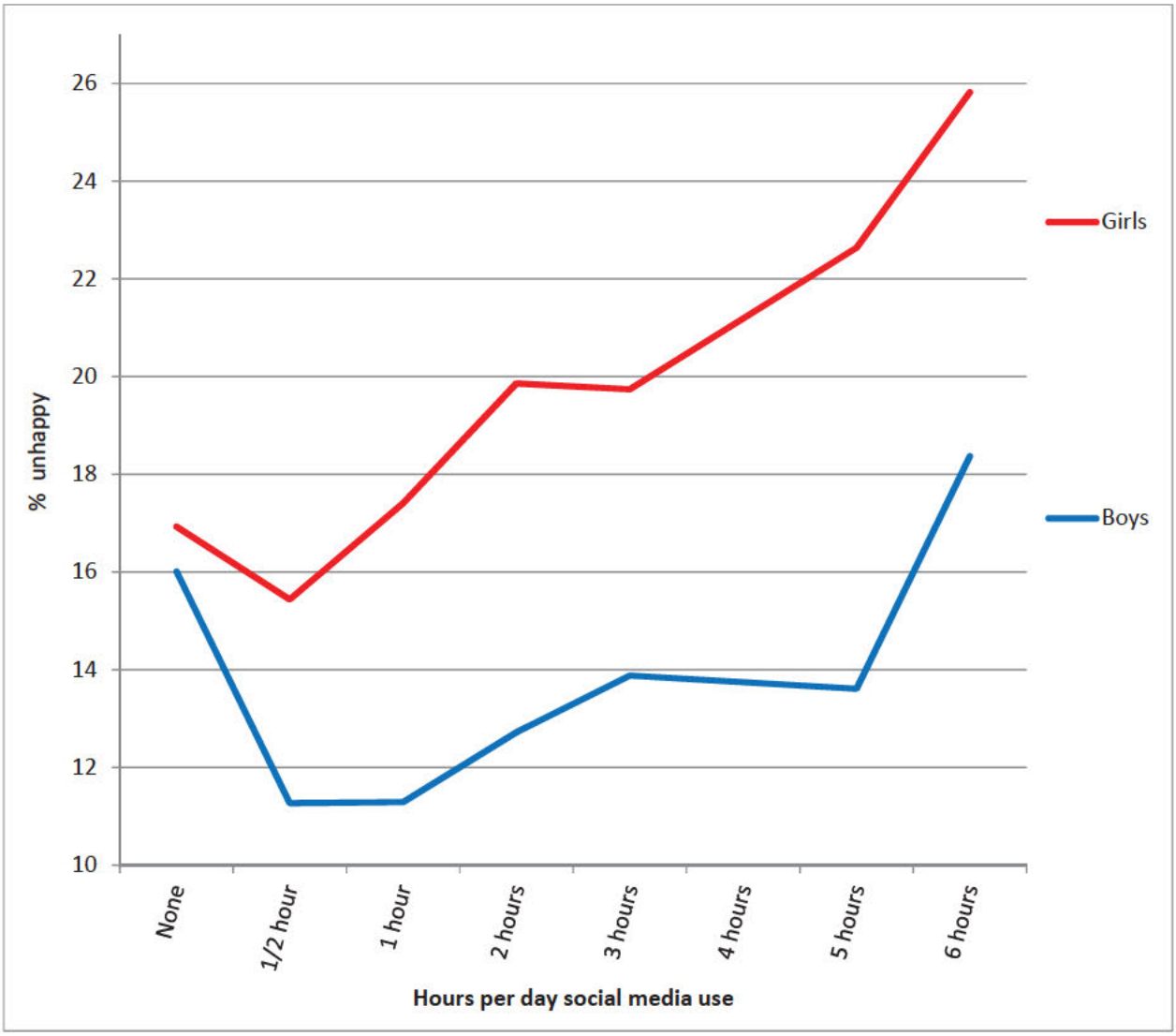

Figure 12: Hours per day of social media use and unhappiness, U.S. teens (8th and 10th graders)
Source: Monitoring the Future. Analyses by Twenge & Martin (2020).
Note: Controlled for grade, race/ethnicity, mother's education, and in-person social interaction frequency.

69. Meta's own internal studies have produced similar results. A Meta study found that people who spend more than an hour a day on Instagram are more likely to report negative mood (agreeing "I felt bad most of the time") (META3047MDL-032-00000933 at META3047MDL032-00000966; META3047MDL-047-00912997, at META3047MDL-047-00913033). It also found that people who spend more than 3 hours a day on Instagram were less likely to agree "I felt happy most of the time" (a measure of positive mood) or that "My life was going well" (a measure of life satisfaction) (META3047MDL-032-00000933, at 966). Meta also

found that more time on social media was linked to a greater likelihood of developing an eating disorder (META3047MDL-020-00250464).

70. Another internal Meta study asked Instagram users how they felt after taking a break from Instagram. Among moderate users (1 to 3 hours a day), 49% said being away from Instagram made them feel better or much better, and only 6% said it made them feel worse or much worse (META3047MDL-032-00000933, at 960). Thus, not using Instagram made half of users feel better.

71. Associations between social media use and poor mental health are generally larger among children and younger teens compared to older teens. For example, Orben et al. (2022) examined data from the UK Understanding Society household survey, which included 72,287 participants aged 10 to 80 years old. Participants completed up to seven surveys between 2011 and 2018. Orben et al. found the largest association between social media use and low life satisfaction during early adolescence (see Figure 13). Similar to previous research, the association was also larger among girls compared to boys (Kelly et al., 2019; Twenge & Martin, 2020). This analysis also found that higher social media use predicted a decrease in life satisfaction one year later (Orben et al., 2022). Thus, social media is more strongly associated with low well-being at some ages than others.

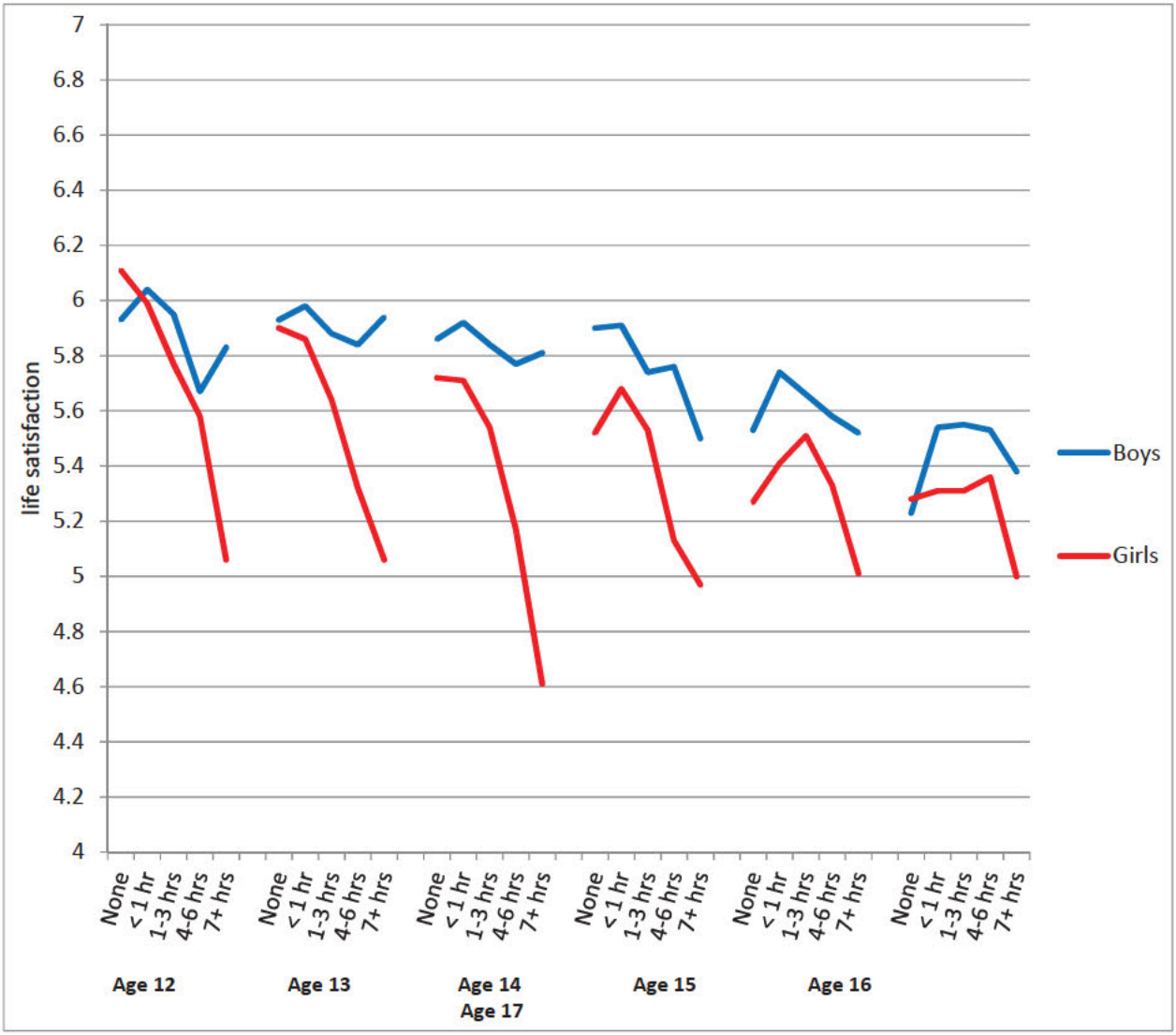

Figure 13: Hours per day of social media use and life satisfaction, by gender and age
Source: Orben et al. (2022)

72. The stronger associations among younger adolescents may be due to sensitivity to negative feedback, which is common on social media. Compared to older adolescents and young adults, early adolescents (ages 12 to 15) were more likely to predict that they would not be liked by others and to experience decreases in self-esteem after social rejection (Rodman et al., 2017). Overall, early adolescents are more vulnerable.

73. Similarly, links between social media use and body image issues are stronger among adolescents compared to adults. Saiphoo et al. (2019) performed a meta-analysis of 63 studies on 36,552 participants, finding that more social media use was linked to greater body dissatisfaction and body image disturbance. Similar to the research on life satisfaction, the association between social media use and body image issues was larger among younger people, specifically adolescents.

Opposing Correlational Research

74. In contrast to the research examined above, Orben and Przybylski (2019) is frequently cited as concluding that social media use is not linked to psychological well-being or worse mental health among adolescents. However, this paper was primarily focused on overall screen time, not social media use specifically; the paper included measures of TV watching, phone calls, and simply owning a computer. One of the paper's analyses (Table 2) did examine hours per day on social media and psychological well-being, finding a correlation of -.056. That means the more hours an adolescent spent on social media, the more likely it was they experienced low well-being, just as in many other studies. The authors argued that this effect was too small to matter.

75. Yet other researchers who looked at the same datasets came to different conclusions. Kelly et al. (2019) did one such analysis, of the Millennium Cohort Study, and found that twice as many heavy social media users were depressed than non-users (see Figure 10, previously). That is not a small effect. Why the difference between the two analyses?

76. It might be because Orben and Przybylski made several unique analysis decisions that are difficult to defend (Twenge et al., 2020). For example, they included one well-being measure, the Strengths and Difficulties Questionnaire (SDQ), 8 times in their analyses (they used the total scale, each of the 5 subscales, and two combinations of subscales) while including the other three well-being measures only once each. Thus the SDQ, which was the only measure based on parent reports rather than teen reports of well-being, was 73% of their data. Because the SDQ showed the smallest correlation with social media use, this had a large impact on the results. When the four well-being scales are treated equally, the correlation between social media use and depression among girls strengthened to -.21 (with no controls; Twenge et al., 2022).

77. In addition, Orben and Przybylski (2019) included controls in their analyses that are potential mediators, including negative attitudes toward school, school grades, and parental distress. Thus, they were controlling away the potential mechanisms behind the link between social media use and depression. Methodologists have explicitly advised against this practice, labeling it "overcontrol" or "overadjustment bias" (Rohrer, 2018; Schisterman et al., 2009). When only demographic controls (such as family income, race, family structure, and parents' education) are included, the correlation between social media use and low well-being among girls is -.20 (Twenge et al., 2022). For comparison, this correlation is nearly twice as large as that between childhood lead exposure and adult IQ, which is .11 (Reuben et al., 2017). The link between psychological well-being and social media use among girls is also larger than that between girls' psychological well-being and binge drinking, marijuana use, exercise, and obesity in the Millennium Cohort Study (Twenge et al., 2022).

78. Semken and Rossell (2022) also examined the same datasets used in Orben and Przybylski (2019), concluding that Orben and Przybylski's analysis was "severely misleading" and led to "statistically invalid conclusions," partially because Orben and Przybylski blended together results across gender, media type, and teen-vs. parent-reported well-being. Semken and Rossell found that the datasets did show meaningful associations between social media use and well-being. For example, they found an odds ratio of nearly 3 for social media use

and depression among girls in the Millenium Cohort Study, identical to the findings of Kelly et al. (2019).

79. Thus, the correlational evidence consistently demonstrates that the more time a teen spends on social media, the more likely it is that they will be depressed, have low well-being, or be unhappy. These associations are significant; in many studies, including the Liu et al. (2022) meta-analysis, twice as many heavy users of social media are depressed compared to non-users.

4.3 Longitudinal studies

80. Longitudinal studies follow the same people over a period of time to examine whether an exposure predicts an outcome. For social media and mental health, these studies often examine whether the level of social media use at Time 1 predicts mental health at Time 2, whether mental health at Time 1 predicts social media use at Time 2, or both.

81. Some longitudinal studies find that more social media use predicts worse mental health on a day-to-day basis (Kross et al., 2013; Verduyn et al., 2015). One recent study (van der Wal et al., 2025) found that adolescents had lower well-being and lower self-esteem on days when they spent more time on social media. The majority of adolescents (60%) experienced consistently negative effects after using social media. These effects were specific to social media platforms such as Instagram and TikTok but did not appear for messaging apps such as WhatsApp. However, other studies examining social media use and mental health day-by-day do not find negative effects (e.g., Mitev et al., 2021).

82. When the time interval is longer – such as a year – most longitudinal studies find that social media use at Time 1 predicts worse mental health at Time 2. For example, Boers et al. (2019) examined 3,826 7th graders from Montreal, Canada who were surveyed once a year for four years and found that increases in social media use in one year predicted increased depression the next year.

83. Viner et al. (2019) analyzed data from the Our Futures study, a nationally representative dataset in England that followed a cohort of 12,866 adolescents from age 13 or 14 to age 15 or 16. Viner et al. found that more frequent social media use among girls and boys at age 13-14 predicted more psychological distress a year later, mostly due to increased sleep deprivation and cyberbullying and declines in physical activity.

84. Riehm et al. analyzed data from the Population Assessment of Tobacco and Health (PATH) study, a nationally representative sample of 6,595 U.S. adolescents. Riehm et al. found a statistically significant association between adolescent social media use and internalizing problems such as anxiety and depression; those who spent more than 3 hours a day using social media were more than twice as likely as non-users to have internalizing problems (Riehm et al., 2019). The association persisted after controlling for pre-existing mental health problems, ruling out reverse causation.

85. Most longitudinal studies that do not find effects have smaller sample sizes than the studies finding effects. For example, Heffer et al. (2019) included only 594 individuals, Coyne et al. (2019) included only 500, and Mitev et al. (2021) included only 116 in

one sample and 120 in the other. These smaller sample sizes make these studies more vulnerable to random variation than the studies with sample sizes in the thousands discussed above. Thus, most longitudinal studies with a time interval of a year or longer and larger sample sizes find that increased social media use predicts worse mental health, and those that do not find effects have smaller sample sizes.

86. In addition, longitudinal studies have identified changes in brain structure due to social media use. Twelve-year-olds who habitually checked social media showed increased activity in the social reward portions of the brain over the course of two years (Maza et al., 2023). Zhao et al. compared brain scans of 5,166 U.S. children at age 9 or 10 to scans taken two years later at age 11 to 12. Those who used social media for more than seven hours a day showed differences in development in several areas of the brain (Zhao et al., 2023).

4.4 Experimental studies

87. Due to the random assignment method, where participants have an equal chance of ending up in either group, experiments can demonstrate scientific causation. The typical experiment examining social media and mental health randomly assigns some participants to give up or reduce their social media use (the experimental group) and others to continue their usual use (the control group). One of the largest experiments using this design randomly assigned nearly 3,000 adults to deactivate their Facebook account for four weeks (the experimental group) versus keeping an active Facebook account (the control group). At the end of the four weeks, those who deactivated their Facebook account had less anxiety and depression compared to those who continued with their normal Facebook use (see Figure 14). They were also happier and had higher life satisfaction (Allcott et al., 2020).

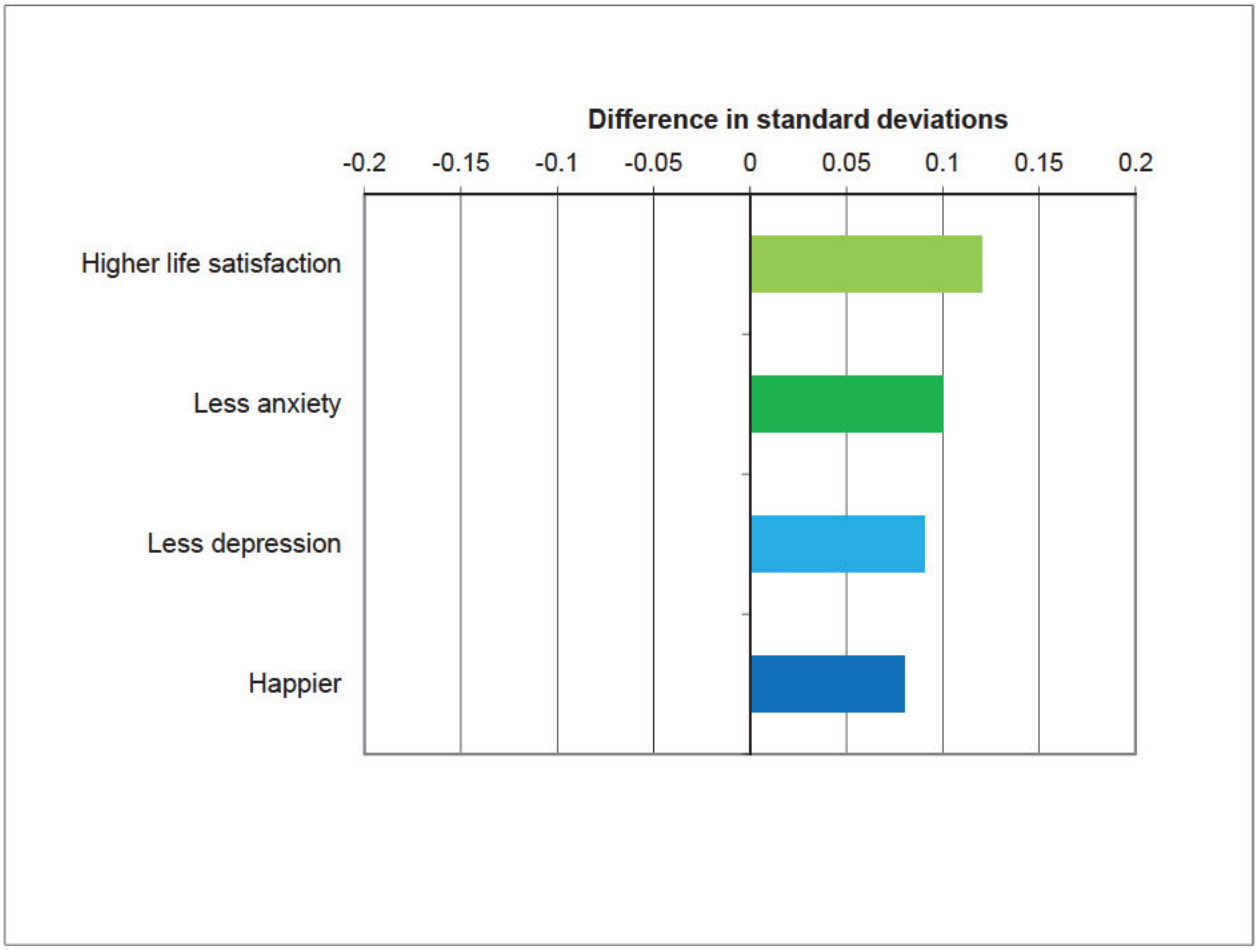

Figure 14: Differences in psychological well-being between adults who deactivated Facebook and those who did not, standard deviations
Source: Allcott et al. (2020)

88. Another experiment randomly assigned U.S. college undergraduates to limit their social media use to 30 minutes a day or less (the experimental group) or to use social media as usual (the control group). After three weeks, those who reduced their social media use were less depressed and less lonely than the control group (Hunt et al., 2018; see Figure 15).

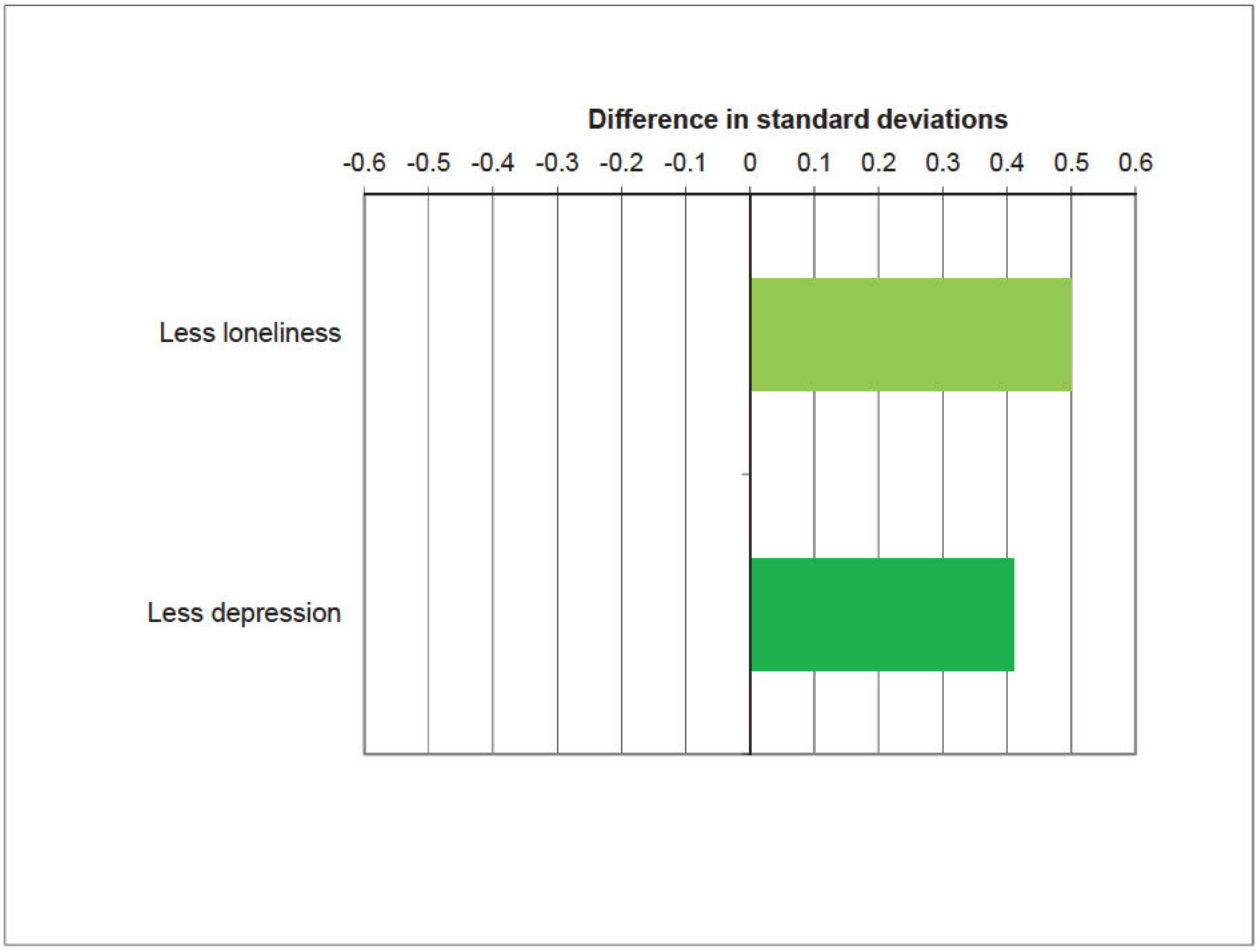

Figure 15: Differences in psychological well-being between college students who reduced their social media use and those who did not, standard deviations
Source: Hunt et al. (2018)
NOTE: Difference in standard deviations (*d*) calculated from two-group *F* and sample size.

89. Another experiment randomly assigned 220 Canadian university students 17 to 25 years old with mental distress to either reduce social media use to one hour a day for three weeks or to continue their usual social media use. Symptoms of depression and generalized anxiety declined significantly more in the experimental group than in the control group (Davis & Goldfield, 2025; see Figure 16).

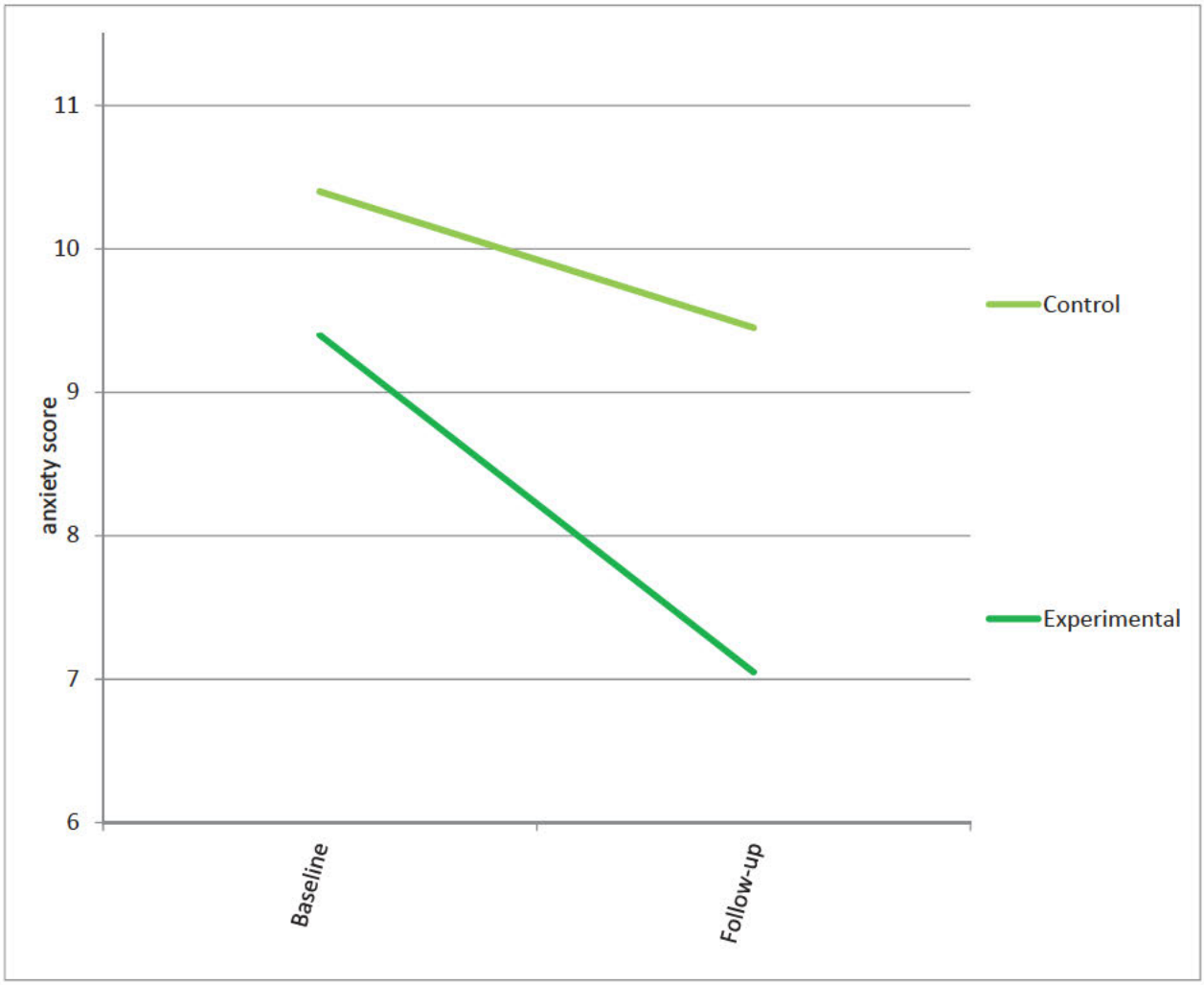

Figure 16: Effect of reducing social media use on generalized anxiety
Source: Davis and Goldfield (2025)

90. Although Davis and Goldfield (2025) included some 17-year-olds, most experiments on social media reduction have included only participants over age 18. A notable exception is a recent experiment that randomly assigned Danish families with children ages 4 to 17 to hand over smartphones and tablets and reduce their leisure screen use to three hours a week or less for a period of two weeks (the experimental group). The experimental group received non-internet enabled cell phones that could call and text but did not have social media apps. Others continued their screen use as usual (control group). Parents were asked to report their children's emotional and behavioral issues using validated measures. At the end of the two weeks, children and adolescents in the experimental group were lower in total emotional and behavioral difficulties, internalizing symptoms such as anxiety and depression, and externalizing symptoms such as anger and acting out (see Figure 17; Schmidt-Persson et al., 2024).

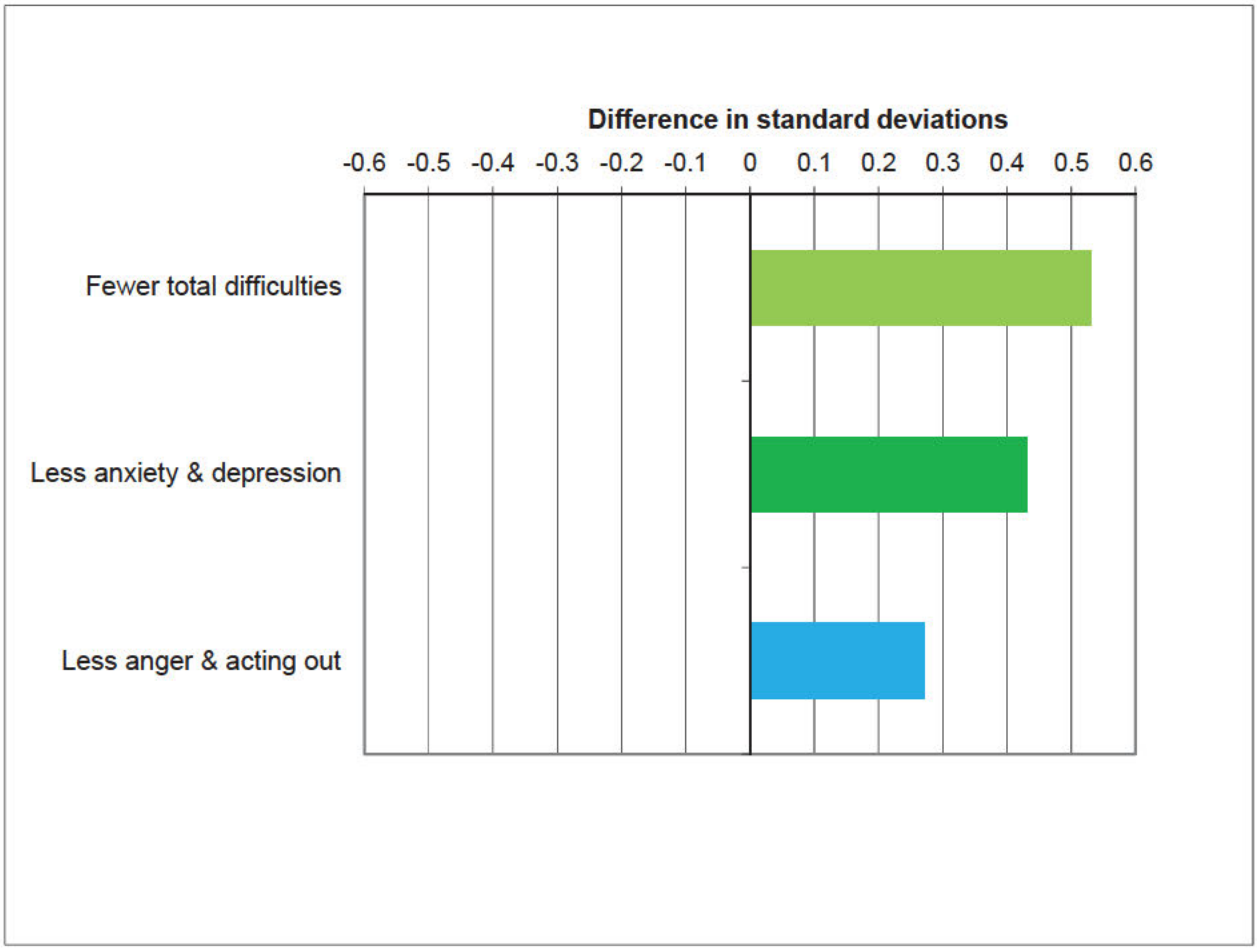

Figure 17: Differences in psychological well-being between youth who reduced screen time and those who did not, standard deviations
Source: Schmidt-Persson et al. (2024)
NOTE: Difference in standard deviations (*d*) calculated from mean change and standard deviations from each group weighted by sample size.

Opposing Experimental Research

91. Some experiments asking undergraduate student participants to eliminate social media use for short periods of time (e.g., a day) have not found improvements in well-being (e.g., Przybylski et al., 2021). However, that result is to be expected as it takes some time to acclimate to not using social media (sometimes known as a withdrawal effect).

92. A meta-analysis by Ferguson (2024) found no significant effect in experiments on reducing social media use. However, this analysis contained numerous errors. For example, Ferguson included two studies that violated his own exclusion criteria (Deters et al., 2012; Gajdics et al., 2022), counted a study showing well-being declining after social media use as showing benefits from social media (Lepp & Barkley, 2022) and used incorrect sample sizes for five studies (Rausch & Haidt, 2024; Stein, 2024). In addition, Ferguson combined the effect sizes from studies of all lengths. Given withdrawal effects, well-being may decline for the first few days after giving up or cutting back on social media. When only the studies lasting a

minimum of a week or more were included, social media reduction or abstinence resulted in a significant improvement in well-being in a meta-analysis that separated the studies in Ferguson's meta-analysis by time interval (Thrul et al., 2025).

93. The studies with interventions of a week or more show a strong causal path from social media use to depression and low well-being. As random-assignment experiments, they can rule out reverse causation and third variables. Thus, they bolster the link between social media use and depression found in correlational studies.

5. Determining causality using the Bradford Hill Criteria

94. Another way to evaluate the causal link between social media use and poor mental health is to apply the Bradford Hill Criteria to the evidence described above. In 1965, while researching the link between cigarette smoking and lung cancer, English statistician Austin Bradford Hill proposed nine criteria that can be used to provide evidence for a causal relationship between a presumed cause and an observed outcome. Bradford Hill emphasized that experimental evidence (randomized-controlled trials) is only occasionally available (as is true in research on social media), so other types of evidence can be used to determine causality (Hill, 1965). The research on social media use and poor mental health fulfills each of the Bradford Hill criteria.

5.1 Criteria 1: The Strength of the Association

95. The strength of the association between two variables can be measured with a statistic known as relative risk (RR), which shows how much more likely someone is to have a negative outcome if they are in one group versus another. For example, a relative risk of 3 means that people in group A are three times more likely to have a negative outcome than people in group B. In Kelly, et al. (2019), the risk of depression was three times higher among girls who were heavy social media users (vs. nonusers), and two times higher for boys (see Figure 10, previously). A meta-analysis found that the risk of depression increased by 13% for each hour increase in social media use among adolescents; thus, moving from no use to seven hours a day increases the risk of depression by 91% on average – thus, it nearly doubles (Liu et al., 2022).

96. Some have argued that the association between social media use and poor mental health exists but is small. That conclusion is based on studies using a statistic called linear *r*. However, linear *r* can be small even when relative risk is large. For example, the linear *r* between smoking cigarettes and developing lung cancer is $r = .06$, even though smokers are 30 times more likely to develop lung cancer than non-smokers, an RR of 30. The linear *r* between wearing a seatbelt and dying in a car accident is $r = .07$, even though people not wearing seatbelts are 3.43 times more likely to be killed in a car accident than those wearing seatbelts (Twenge & Hamilton, 2022).

97. In addition, the linear *r*'s between social media use and poor mental health are similar to or stronger than many factors considered relevant for public health. Researchers on both sides of the debate agree that the correlation between social media and poor mental health is somewhere between .10 and .24 (Orben, 2020; Twenge & Farley, 2020). The correlation between childhood lead exposure and adult IQ is $r = -.11$ (Reuben et al., 2017). The correlation

between poor mental health and obesity is $r = .10$, and with marijuana use is $r = .15$ (Twenge et al., 2022).

98. Thus, the association between social media use and poor mental health is strong when considered using relative risk, and strong when compared to other factors relevant for public health.

5.2 Criteria 2: Consistency

99. If an effect is consistent, it has been repeatedly observed by different people and in different places. The association between social media use and poor mental health is consistent: Across correlational studies, heavy social media users have worse mental health than light or non-users (Liu et al., 2022; Orben, 2020). The increase in mental health issues since 2010 among adolescents is also consistent across many regions of the world, including in the U.S., Europe, English-speaking countries, and Latin America (Boer et al., 2023; Schrijvers et al., 2024; Twenge et al., 2021).

5.3 Criteria 3: Specificity

100. Specificity refers to the absence of any other likely explanation for most of the increase in prevalence (in this case, depression and poor mental health). As shown in section 4.1.2, no other explanation for the increase in adolescent depression fits the data as well as the increasing popularity of social media and smartphones.

5.4 Criteria 4: Temporality

101. Temporality means that the exposure (social media) must occur before the disease (poor mental health). Evidence for temporality comes from two different sources. First, time-series "natural experiments" show social media increasing in popularity before mental health begins to suffer. For example, after Facebook was introduced on a college campus, students' mental health later suffered (Braghieri et al., 2021). In addition, Granger causality analyses showed that time spent online and smartphone adoption preceded a rise in unhappiness among adolescents by a year (Twenge et al., 2018b). Second, as shown in section 4.3, most longitudinal studies lasting months or more show that social media use occurs first, followed by poor mental health.

5.5 Criteria 5: Dose-response relationship, sometimes called a "biological gradient"

102. The Bradford Hill (1965) paper states: "[I]f the association is one which can reveal a biological gradient, or dose-response curve, then we should look most carefully for such evidence. For instance, the fact that the death rate from cancer of the lung rises linearly with the number of cigarettes smoked daily, adds a very great deal to the simpler evidence that cigarette smokers have a higher death rate than non-smokers."

103. The association between social media use and poor mental health shows a clear dose-response relationship: The more time an adolescent spends on social media, the more likely it is they will be depressed (see Figure 11 in section 4.2). In addition, experimental studies

show that cutting back on social media use improves mental health. Thus, social media use shows a biological gradient similar to alcohol or cigarettes.

5.6 Criteria 6: Plausibility

104. The Bradford Hill paper states, "[b]iological plausibility … depends upon the biological knowledge of the day" (Hill, 1965). As discussed above, people with frequent and problematic social media use can experience changes in brain structure and development. Social media changes the brain through many mechanisms, including through addictive design features that activate the brain's reward pathway (Meshi et al., 2013). Eleven-to 13-year-old adolescents who habitually checked social media showed distinct changes in their brains' sensitivity to the anticipation of social rewards and punishments (Maza et al., 2023). Thus, social media has plausible biological mechanisms.

5.7 Criteria 7: Coherence

105. Bradford Hill argued that "the cause-and-effect interpretation of our data should not seriously conflict with the generally known facts of the natural history and biology of the disease" (Hill, 1965). That is the case for social media and poor mental health: Time-series studies show that with greater use of social media, youth mental health declined. This evidence, as well as the dose-response relationship shown in the correlational and experimental studies, is consistent with biological plausibility.

5.8 Criteria 8: Experiment

106. Bradford Hill emphasized that experimental (random-assignment or randomized-controlled trial) evidence is rare, especially in situations like these that require involving a vulnerable population (in this case, minors), thus presenting ethical concerns. Bradford Hill wrote that only "[o]ccasionally it is possible to appeal to experimental, or semi-experimental, evidence." Even with this limitation, most experiments measuring mental health after the initial period of withdrawal from social media demonstrate a causal link between reduced social media use and better mental health (see section 4.4, previously).

5.9 Criteria 9: Analogy

107. Analogy involves comparing two bodies of evidence, one of which has an established causal relationship, to infer causality in the other body of evidence. For social media, that might mean comparing social media addiction to drug or alcohol addiction. Similar to substance use, social media use can become compulsive or addictive; people can find it difficult to control their use, crave social media, and experience withdrawal if they do not use social media. In MRI scans of more than 10,000 adolescents, heavy users of digital media showed structural brain features that resembled those previously found among adolescents who began drinking alcohol at early ages (Zhao et al., 2022).

6. Conclusions

108. The totality of the evidence, including from time series, correlational, longitudinal, and experimental studies, demonstrates that social media use is a causal factor in the youth mental health crisis. Time series studies show that adolescent depression increased in tandem with smartphone and social media use, with no other explanation fitting the data. Correlational studies consistently show that the more hours an adolescent spends using social media, the more likely it is they are depressed or unhappy. Longitudinal studies with a time interval of a year or longer and with larger sample sizes find that increased social media use predicts worse adolescent mental health. Experimental studies show that reducing social media and screen use improves well-being. The evidence as a whole thus demonstrates a causal path from social media use to depression and low well-being, and fulfills all of the Bradford-Hill criteria for establishing causation.

109. The undersigned hereby certifies their understanding that they owe a primary and overriding duty of candor and professional integrity to help the Court on matters within their expertise and in all submissions to, or testimony before, the Court. The undersigned further certifies that their report and opinions are not being presented for any improper purpose, such as to harass, cause unnecessary delay, or needlessly increase the cost of litigation.

Date: 05/15/25 | 4:56 PM PDT

DocuSigned by:
Jean Twenge
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Jean M. Twenge, Ph.D.

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